Power and The Engineer

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THE all absorbing topic is wages. At least, so it would appear from the amount of space which it gets in the magazines. And, doubtlessly, so it is with a large class of men.

In a certain respect this is but natural. Wages mean power. Not only the necessities of life, but almost anything in the world, except contentment, can be obtained for money.

According to a man's tastes, wages mean various things.

To one man better wages mean greater ability to "crowd on a better front"—wear bigger, brighter studs; smoke cigars with more gorgeous bands, and show in other ways how much money he can spend without half trying.

Another man desires more wages so that he can play stronger at the fascinating game of chasing dollars into a bank account.

More wages, to a third man, means a feeling of greater security against privation.

And so we could go on through the whole category of desire and show that each of the items therein is a motive of the struggle for larger remuneration.

Some of the reasons why men desire more wages are laudable; many are not.

We contend that peace of mind is of far greater importance than the gratification of many of the desires which actuate the strife for higher wages.

Please do not conclude from this that we are not for higher wages. We are—*strong*.

We believe, however, that much dissatisfaction is simply the result of not realizing when we are well off.

After all, *position* is everything.

One of our subscribers in the West, wrote: "I am a fireman on a tugboat. Now, there is more honor in being a fireman and taking orders from an intelligent, experienced engineer than there is in being an engineer and taking orders from an educated ass."

This is good, sound philosophy. Not everyone can be the chief engineer. Not everyone wishes to be, as the quotation plainly testifies. Although the chief gets many more "ducats" than does our subscriber, the latter does not appear to be envious in the least.

If your position "fits" you, "stick." If you like the work, can do it satisfactorily and if the "man higher up" is a "white man," hold fast to your job even if your wages are not quite as high as those paid to Ernest Browbeaten by Hector Loudmouth, at the next plant above. Ernest probably earns, by his meek submissiveness, several times what he really gets.

It is unsatisfactory business to sacrifice self respect and dignity for a few extra dollars. Life is too short. We believe that if you improve your worth to your employer and become deserving of a better position and better wages, you will find that your wages will improve in proportion. Opportunity comes to everyone. Be ready when your turn comes.

When you have a real grievance, *kick*. But don't, above all, be a common "sore head."

Laboratories at University of Toronto

By Prof. R. W. Angus

The steam, gas and hydraulic laboratories at the University of Toronto, which were completed during the past year show the result of much forethought on the part of those responsible for their design. They are laid out with a view to meeting the peculiar needs of instruction in these departments and the equipment is fairly complete.

The laboratories described in the present article were built and ready for students in October, 1909. They occupy an entire building which is divided into two distinct parts by a wall running the full length of it, the part to the north of this wall being used for hydraulic work and for offices and study rooms, while the part to the south contains the heat engines and other similar apparatus, and in a separate room the boilers. The building has a length of over 200 feet and a width of about 100 feet, the hydraulic section being three stories high, while the remainder of the building is but one story.

At the present time the board of governors of the university have not deemed it advisable to complete the building, so that the front has not yet been erected, although the laboratory section is now complete. The total cost of the part erected to date exceeds $85,000 exclusive of equipment, for which $22,000 has been spent. As a considerable amount of apparatus was moved from the old laboratories, however, the actual value of the equipment would exceed the above mentioned amount.

Steam- and Gas-engine Laboratory

Beginning with the south side of the building devoted to heat engines, one enters a large room 156 feet long by 60 feet wide, lighted throughout from the roof, there being no windows in any of the walls. This room is divided on one side into eight smaller rooms, each 15x20 feet which are used for special apparatus, to be described later. The main part of this large division which is 40 feet wide and the full length of the building, contains all of the engines, and is served throughout by a three-ton traveling crane.

This arrangement has proved admirable, the lighting is as nearly perfect as possible, the ventilation has been found good, and the arrangement of the engines is convenient, while the smaller rooms give students a chance to work quietly on smaller experiments.

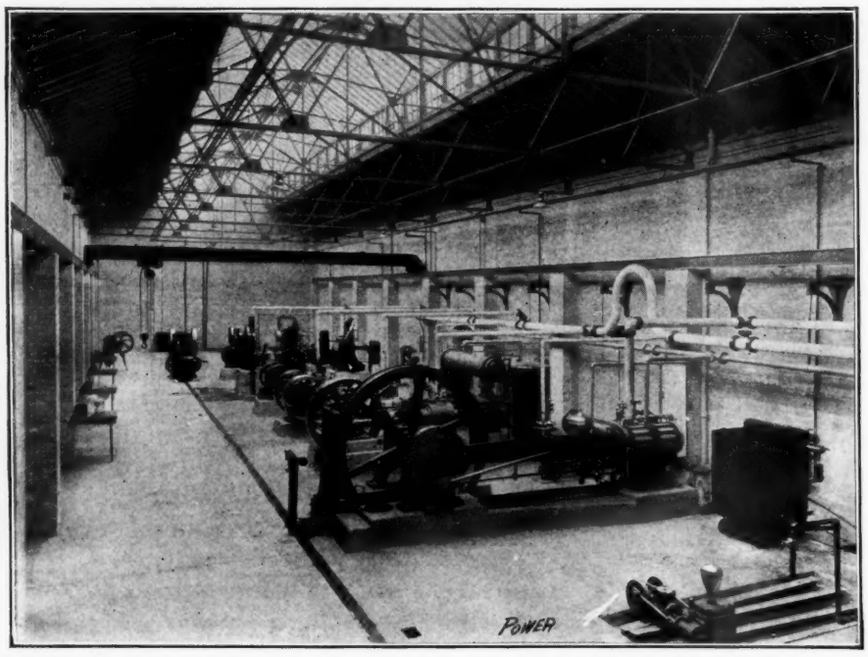


Fig. 1. Steam- and Gas-engine Laboratory, Looking West

Fig. 1 gives a general view of the main part of this room, in which the gas engines are placed across one end and the steam engines along the entire side. Fig. 2 is a photograph of the same room taken from the other end and showing the row of small rooms. There are four gas engines, one of 10 horsepower built by Fielding & Platt, and arranged for burning city or suction gas, or liquid fuel. Adjacent to this is a 22-horsepower gas engine built by the National Gas Engine Company, and like the other has specially heavy wheels, both engines having arrangements for variable compression. The third is an old Otto machine of historic interest. A suction gas producer for use with these engines has been placed in one of the small rooms to avoid annoyance from gas and dirt. A Fairbanks marine gasolene engine completes the list of internal-combustion machines, but mention may be made of test floors which have been arranged for any machines of this type which may be loaned to the laboratories for purposes of investigation. An Ericsson hot-air engine also forms part of this equipment.

Of the steam engines there are two Leonard engines, one 6x8 inches, the other 7x8 inches, both of which are arranged especially for valve setting and indicator practice; an 18-horsepower McEwen; a 12x10-inch Leonard-Ball tandem-compound engine of 29 horsepower; a 50-horsepower Brown engine, jacketed and especially arranged for research work; a 75-horsepower Williams engine, and a 15-horsepower De Laval turbine with six nozzles, condensing and noncondensing. There is also a Rand air compressor with compound steam cylinders and two-stage air cylinders, having a capacity of 340 cubic feet of air per minute at 100 pounds pressure. The steam valves of this machine are of the Meyer type and a Corliss inlet gear is used on the low-pressure air cylinder.

A large test floor has also been arranged in connection with the steam work for the study of engines which may be loaned from time to time.

The arrangement of the steam and exhaust piping and condensers is of some interest and considerable care has been taken in devising a scheme suited to the peculiar needs of a laboratory. It is desirable to have an arrangement permitting of the use of all the engines at the same time, and in order to measure the steam consumption of an engine, a surface condenser is necessary; hence a condenser would have to be provided for each engine if the steam consumption of each were to be measured at the same time. Such an arrangement was deemed too expensive and only two condensers have been installed. The piping permits the simultaneous running of any two engines condensing, while at the

same time all of the other engines may be run noncondensing.

In order to accomplish this a large trench was made in which were placed two parallel 6-inch exhaust-pipe lines, one of which passes to a Cochrane heater and thence to the atmosphere, while the other is connected to two surface condensers. The exhaust from each engine passes under one of these pipes and turns upward by means of an elbow; on top of this elbow is a second one which may, by turning through 180 degrees, be connected by a tee to either of the exhaust lines. Thus it becomes a very simple operation to run an engine which ever way desired. The arrangement has worked very successfully during the past session. Of course, proper drains have been provided throughout.

Two Wheeler surface condensers with separate air pumps have been installed in connection with the above scheme, the circulating water being handled separately.

The main steam pipe is 5 inches and runs from the boilers along the side of the building, connections to the engines being from the top so as to avoid water draining to them. The fittings are all extra heavy and two expansion bends have been inserted, one in the boiler room and the other in the main engine room, the latter bend being visible in Fig. 1.

In addition to the above steam main, a special 3½-inch pipe runs from one of the 50-horsepower boilers to the Brown engine, so that a feed-water test on the engine may be made when desired. Connections have also been made so that this boiler may deliver steam to the 5-inch main and the Brown engine may in turn draw steam from this main.

All the engines are arranged with brakes of a very simple construction, the writer believing that the simpler the apparatus, consistent with accuracy, the greater will be the value of the instruction.

Of the eight smaller rooms on the south side of the main steam laboratory, the first two are connected and are used as a small repair and instrument-making shop, and are equipped with a lathe, drill press, etc. This shop is not used for instruction to students but merely to make necessary repairs to the machines.

The next room will contain the belt- and rope-testing machines, the power put into the belt being determined by an Amsler torsion dynamometer. The fourth room contains a completely arranged three-ton York steam-driven refrigerating plant.

Of the remaining four rooms, one contains the 20-horsepower suction-gas plant, already mentioned; another contains oil- and fuel-testing apparatus of various kinds; while the third has been set apart as a study room. The remaining room is used for instruments, and is arranged and managed as nearly as possible like the tool room in a shop, each student handing in a list of the instruments required for his experiment and being held responsible for their return in proper condition at the close of the day. This method has been very effective in checking the loss or damage of apparatus.

The Hydraulic Laboratory

The hydraulic laboratory occupies the greater part of the north half of the building and is located on the basement and ground floors, each of which is 40 feet wide and 113 feet long. It was impossible to obtain such perfect lighting for this laboratory as for the engine room on account of having to take light from the side, but very good results have been obtained by the use of large windows which occupy fully three-fourths of the total wall space, and it is thus comparatively easy to work during any but the darkest days without the use of artificial light.

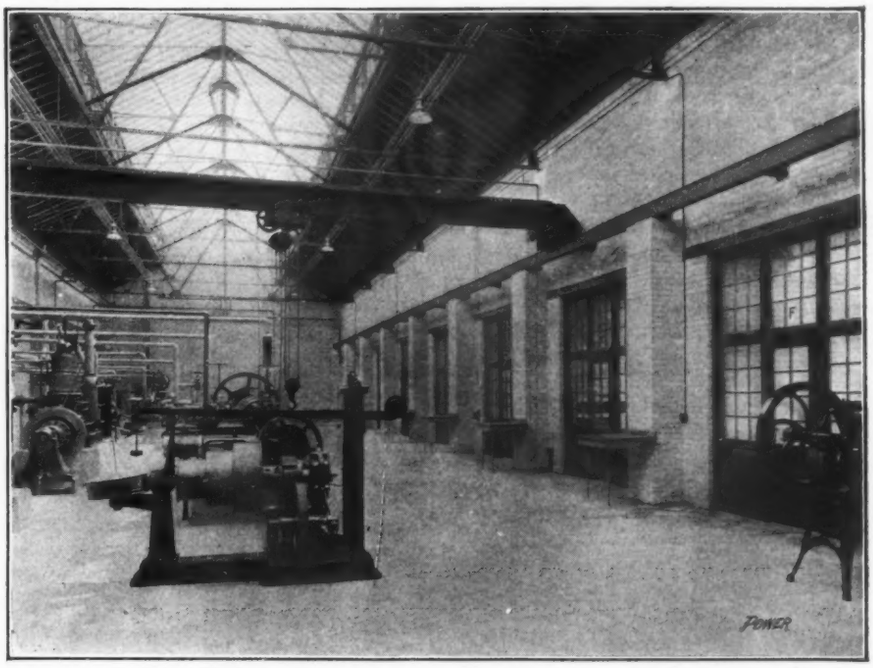


Fig. 2. Steam- and Gas-engine Laboratory Showing Small Rooms

The lower story, or basement is 18 feet high and contains the well, the pumps and the engine for driving them, the measuring tanks used for calibrating the orifices and weirs above, several large troughs and the main part of the piping for the entire laboratory. The upper floor, which is 15 feet high, contains the orifice and weir tanks, the experimental centrifugal pump with its weir tank and motor, the various pipes for friction experiments, the meters, and also the various types of turbines and other apparatus.

Beginning with the top floor at the west end, see Fig. 3, the first piece of apparatus is a centrifugal pump of special construction for experimental work. This pump, which is driven by a variable-speed motor, is mounted on a weir tank so that the discharge may be easily measured, the various heads under which it is operated being obtained by throttling.

Adjacent to this are two orifice tanks and a weir tank used mainly for instruction in the use of orifices and weirs. The water is discharged through 6-inch pipes into calibrating tanks below, of which there are six, two for each orifice and weir. These calibrating tanks have been designed so as to be operated entirely by the movement of a single lever. When the lever is put in one extreme position, one tank is made to fill, its outlet valve being closed, while at the same time the outlet valve of the other tank is open. For small discharges the tank fills so slowly that the upper surface of the water is quite smooth and undisturbed, and therefore the exact hight of the water in the tank, and consequently the volume of the water at the moment of dumping is easily observed; but where the discharges are large the surface of the water in the calibrating tank is so disturbed that accurate observations of this kind are impossible. To obviate this trouble the mechanism is so designed that by moving the lever to an intermediate position the outlet valve on the other tank is closed and the discharge is turned into it. The water surface in the first tank comes to rest at once and its hight is easily measured; after which the lever is pushed to the other extreme position and the outlet valve of the first tank is opened without disturbing the conditions in the second tank. The quantity of water in the tank after filling may be found by direct weighing or by reading the level in an attached gage glass.

An opening in the floor protected by a rail enables the student to observe the whole operation at one time.

In order that experiments on these

tanks and orifices may be carried on without interfering with the other work, a large reservoir provided with an overflow has been placed above them and from this the water is drawn. So long as there is enough water passing into the reservoir to cause some overflow, the experiments may be carried on at various heads and the water discharges without difficulty. Water from this reservoir also drives a hydraulic ram.

A 3-inch Venturi meter has been installed on a pipe in which other meters will also be placed. This meter is rated by sending the discharge from it through one of the orifice tanks already described, and using the coefficient determined by actual experiment.

Near the center of the laboratory an elevated platform has been erected for the two impulse turbines, one of which is a 12-inch Doble wheel with glass sides enabling the action of the water to be studied conveniently; the other is an 18-inch Pelton wheel. The water used passes over a weir and then back to the pump well; for the use of these turbines with or without end contractions, may be easily inserted. The weirs used are calibrated by means of a pair of measuring tanks located in the basement, each holding approximately 240 cubic feet.

There are three reaction turbines; the smallest one has a 6-inch runner and has been set up in a steel penstock and connected to the standpipe by a 14-inch steel pipe containing two elbows. This pipe is to be used for experiments on the flow of water, the conditions being examined by a Pitot tube. The turbine has been operated under a total head of over 25 feet; the horsepower is measured by a Prony brake and the discharge is determined from the 4½-foot weir. There is also a 9-inch McCormick wheel.

The latest turbine is one purchased recently from the firm of Escher, Wyss & Co., Zurich, Switzerland. This wheel is of the horizontal Francis type and has a spiral casing and 14-inch runner; the gates being operated through a ring by a handwheel on the casing. A conical draft tube over 7 feet long is used and the wheel will deliver 10 horsepower two-stage pumps bolted to a common bedplate and driven by a single pulley, the couplings being arranged so that either pump may be operated separately. Further, the two pumps on the one base are piped together in such a way that they may be made to deliver to the line in three ways, viz., separately, in series and in parallel. A connection is also arranged to connect the discharge from one pump to the suction from the other pump, thus placing the two sets in series for high-pressure work.

Each set of pumps will deliver 1 cubic foot of water per second, one set acting against a head of 125 feet while the other will deliver against a head of 150 feet; the discharge at lower heads being, of course, much greater.

The arrangement of the plant is very flexible, permitting the operation of the four pumps separately, thus allowing four absolutely independent experiments at one time; the operation of the two sets separately on separate experiments; the operation of the two sets in series for high pressures and moderate discharges

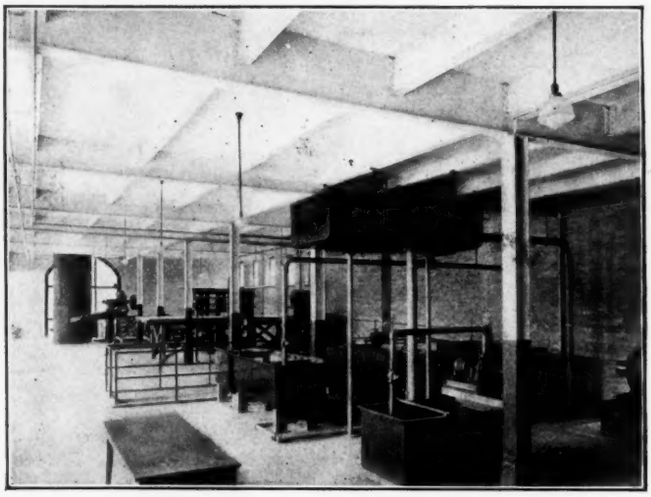


FIG. 3. HYDRAULIC LABORATORY, TOP FLOOR

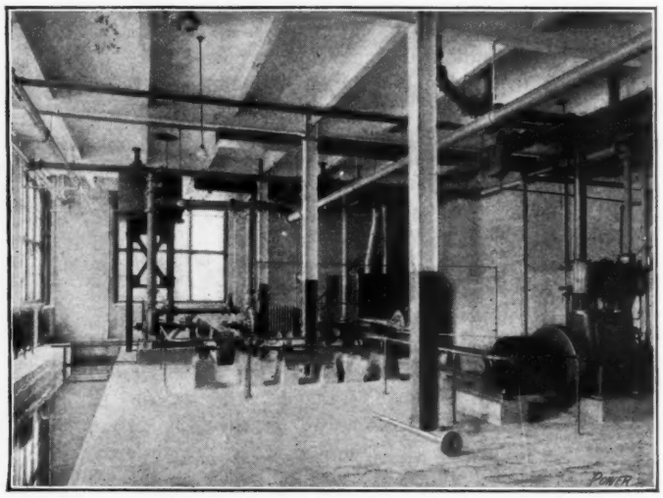


FIG. 4. HYDRAULIC LABORATORY, BASEMENT

it is possible to get a discharge of 1 cubic foot per second against a maximum head of about 500 feet.

At the east end of the room is a large standpipe 32 feet high and 5½ feet diameter, which is used as a reservoir for the reaction turbines and also for any experiments requiring constant head. This standpipe has nozzles for the attachment of turbines and orifice plates and tubes of various sizes. The water is delivered to the standpipe through two pipes near the bottom, and by an arrangement of baffle plates there is no trouble caused by the surging or eddying of the water.

In front of this standpipe is a large weir tank 20 feet long by 6 feet wide, which is arranged with a sharp-crested weir 4½ feet wide, with end contractions. This plate may, however, be changed so that weirs of different sizes, when supplied with 6 cubic feet of water per second at a head of 20 feet.

Along the north side of this floor near the windows, arrangements are made for the testing of the friction in fire hose and pipes. A 2½-inch iron pipe 50 feet long has been set up, also a 50-foot length of fire hose in which the frictional losses are determined. The flow in the iron pipe is studied by a Pitot tube.

The basement, shown in Fig. 4, contains, in addition to the orifice and weir calibrating tanks already mentioned, the well and pumping plant; all water used in the laboratory being drained back to a large well from which it is pumped into the system and used again.

There are two sets of turbine pumps used for this purpose, one of the Gwynne type and the other of the Escher & Wyss type. Each set consists of two such as are required in fire streams and impulse turbines; and the operation of the two sets in parallel, giving about 6 cubic feet per second at the heads available in reaction-turbine work in the laboratory.

The pumps are of modern design and are belt driven from a jack shaft placed on the floor to avoid vibration. The jack shaft is driven by a Belliss & Morcom engine of 130 horsepower running at 530 revolutions per minute. The exhaust from this engine is used to heat the building.

A large trough 6 feet wide, 4 feet deep and 110 feet long has been provided in the basement for the rating of current meters and tubes and other work of this nature. It is believed that this will be especially useful in view of the rapid advance in water-power development at the present time.

The Boiler Room

This room is 70x45 feet and contains three Babcock & Wilcox boilers, all built for 200 pounds pressure, and having separate feed pumps.

The 100-horsepower boiler is provided with a superheater, while the two 50-horsepower boilers have been set up independently, one being arranged with a special type of setting so that comparative results may be obtained.

A steel breeching conducts the products of combustion to two 36-inch by 100-foot brick stacks. An arrangement of dampers allows these stacks to be operated simultaneously at different powers and thus reliable experiments may be made on the capacity of each stack.

Offices and Study Rooms

At the northwest corner of the building, just west of the hydraulic laboratory, is a space occupied by the stairways, halls and other rooms. These rooms are as follows: In the basement, the students' room with shower bath, on the first floor the professors' and lecturers' rooms, while the top floor is occupied by a lecture room and a private lavatory.

The entire floor above the hydraulic laboratory is divided into students' study rooms, a lecture room, a library, a demonstrators' room and a students' lavatory. All of these rooms are comfortable and bright, and the students' rooms are provided with convenient tables and a locked drawer for each person.

Artificial Lighting

The large thermodynamic laboratory is lighted by ten Nernst lamps, which are attached to the trusses and provide sufficiently good light to do any work required at night. The hydraulic laboratory is lighted by Tungsten lamps, there being ten to each floor.

The remainder of the building, with the exception of the boiler room, which also has Nernst lamps as well as incandescent lamps, is lighted entirely by incandescent lamps.

Selection of Lubricating Oils

By Charles B. Arnold

Owing to their superior qualities, mineral oils are now almost universally used for the lubrication of cylinders and other parts subjected to high temperatures. In the selection of these oils the flash point, specific gravity and viscosity must be carefully considered, as certain operating conditions require certain values for these factors.

Of the many supplies used in a power plant, the lubricating oil is one of the most important, and it is essential that only oil of the proper quality be selected for the various bearings and cylinders.

Of the numerous kinds, there are animal oils, found in small animal substances such as lard and sperm; vegetable oils, such as rape oil made from a French turnip and castor oil obtained from the seed of a plant grown in the West Indies; and lastly mineral oils, from which the greater part of our lubricants are made. Formerly only animal and vegetable oils were used to lubricate the cylinders, but it was found that they decomposed under high heat and generated acids which corroded the metal of the cylinders, and further, when using condensers and returning the condensation to the boilers, these oils led to the corrosion of the boiler plates. This objection was removed by the introduction of proper mineral oil for cylinder use.

The amount of oil cannot be estimated exactly by counting the drops, as one cylinder oil may feed more at the rate of three drops a minute than another at six drops a minute. Consequently, when it is desired to ascertain the amount used in a certain time, it is necessary to measure the oil instead of counting the drops.

For use in a cylinder where the steam pressure is less than 100 pounds per square inch, the oil should show a flash test of not less than 590 degrees nor more than 630 degrees Fahrenheit, and for pressures over 100 and up to 200 pounds, the flash test should be from 640 to 660 degrees. The specific gravity of a cylinder oil showing a flash test of 600 degrees should be from 26 to 27, and for a flash test of 660 degrees, from 24 to 25.

Cylinder oil with a high flash point, when used in a cylinder carrying a low steam pressure, will not give satisfactory results, as the heat is not great enough to thoroughly atomize the oil, which passes through with the steam without thoroughly lubricating the surfaces of the cylinder. On the other hand, an oil of a low flash point should not be used with high-pressure steam, as it loses its lubricating qualities and passes out of the cylinder without doing its work.

For the cylinder the pure mineral oil is the best, and it is not necessary to compound it with animal or vegetable oil. Some engineers insist upon using tallow with their cylinder oils and if this is done, nothing but refined tallow should be used, never common lump tallow, as it contains acid which attacks the cylinder walls and leaves charred particles in the steam. Cheap grades of cylinder oil are often adulterated with wool fat, which is used to cut the gummy ingredients and give the oil a good flow in a cold test. Wool fat, however, causes a separation and a thick deposit in the bottom of the barrels, resulting in the same charred deposits in the cylinder as with lump tallow. In the report of the annual meeting of the Engine Builders' Association, the following statement was made: "The lubrication of the cylinders of engines, where superheated steam is used, is apt to cause a great deal of unnecessary anxiety to one not experienced with superheated steam." This problem is very simple, however, if it is borne in mind that the temperature inside the cylinder is never very high, even when the superheat at the entrance is considerable; and if the cylinder is lubricated direct without mixing the oil with the steam at the entrance point, there will be no difficulty, provided a good grade of mineral oil is used.

The value of any kind of liquid for external lubrication depends to a large extent upon its viscosity. The viscosity of the oil changes directly with the temperature; as the temperature increases the oil will flow more freely and have less body. An oil of high viscosity should be used in a room where the temperature is high, as the greater the viscosity of the oil the thicker will be the layer or film between the rubbing parts.

Flat surfaces, such as the guides of an engine, are more difficult to keep lubricated than the journals. The latter in turning form an unbroken film of oil, and if there is a continuous supply this film will remain unbroken. The oil wedges itself between the journals and bearings and keeps them apart, and as long as this film is maintained, the journal and bearing do not come in contact, therefore causing no wear. If there are high places on the bearing or if grit thicker than the film of the oil gets in the bearing, heating will result, the high places heating first; the oil will then become thinner, leaving this part of the bearing where it is needed most and flowing to the cooler parts. The fact that the journal runs without heating is no proof that the friction cannot be reduced. An oil should be selected of the right viscosity for the speed of the journal, the pressure on it and its fit with this bearing. A loose-fitting bearing

requires a heavier oil than one which runs with a perfect fit.

A pure mineral oil is found to be the best for external lubricating purposes and is more generally used. Vegetable and animal oils are apt to become sticky and gummy, and do not work well. Engine oils for high speeds should show a viscosity of at least 170 and should range up to 195 at an ordinary temperature of about 75 degrees. The oil should show a specific gravity of about 30 and the flash test should be between 400 and 450 degrees Fahrenheit. In the case of a slow-speed engine the oil should have a viscosity of from 195 to 215 and a specific gravity of 24, with a flash test between 440 and 460 degrees.

Much attention has been given to the reduction of steam consumption per horsepower, but when it is considered that in small- and medium-sized engines working at full load, 8 per cent. of the power, and at one-quarter load 35 per cent. of the power developed is wasted in journal friction, there seems to be much room for improvement in this line.

The Efficiency of Waterwheels

By Henry D. Jackson

The angle at which water enters and leaves; the friction in guide vanes, buckets and bearings; and leakage between runner and case, all influence the efficiency of a waterwheel, which seldom exceeds 80 per cent. under actual operating conditions.

In many cases owing to the impossibility of testing waterwheels, guarantees of performance are made which are considerably beyond what can actually be accomplished. It sometimes happens that after a wheel is installed, owing to some change in the situation, a test is made possible and the results show that the wheel is not developing anything like what was guaranteed. On an occasion like this, it is not unusual to find that the wheel manufacturer easily points out why the test as made does not show the true efficiency of the wheel; he will claim that the test should not take into account various items which do really enter into the wheel efficiency.

Many wheel manufacturers bring forward tests to show remarkable efficiencies for their wheels, and it is not infrequent to hear of moderate-size wheels showing efficiencies as high as 93 and 94 per cent. and of larger ones showing even higher efficiency. It is very easy to make tests which will show efficiencies of over 100 per cent. if the investigator has not had a wide experience in testing wheels and in measuring the flow of water. A study of waterwheel construction and efficiency will readily show one that extremely high efficiencies, in the nineties, are impossible, except under ideal conditions.

The efficiency of a waterwheel depends upon a great many things. For the best efficiency, the water should enter the wheel tangentially and leave radially. The angle at which the water actually can enter or leave is limited by the mechanical construction of the wheel. The actual direction of the water entering the buckets depends upon the speed of the wheel. The actual direction of the water as it leaves the buckets should be nearly radial so that the energy in the water leaving the wheel will be small. The velocity at the entrance rim depends on the type of the wheel, and bears a definite relation to the spouting velocity of the water. Owing to the fact that it is not possible closely to approximate the theoretically best conditions for either the entrance or exit of the water, there is a considerable loss both as the water enters and leaves. There is also a considerable loss due to the velocity of the water as it leaves the wheel, as it is necessary to have this velocity in order that the water will free itself from the wheel and not choke the discharge passages.

These are also considerable losses of energy due to friction in the guide vanes, friction in the buckets themselves, leakage between the runner and the case and the friction of the bearings in the various parts of the wheel. These losses are of the wheel itself. In addition to these, there are other possible losses due to getting water to and from the wheel, which, if not carefully taken into account, may be very considerable.

In many of the tests reported by waterwheel manufacturers, no account is made of any of the losses existing outside of the wheel itself. In many of the guarantees made by the waterwheel manufacturers, unless the purchaser is wary, he will find when the test is made, that the guarantee simply covers the power delivered by the wheel at the wheel shaft with a head determined exactly at the wheel, and that no account is made of the losses which may exist in other parts of the installation, which should be and frequently are a part of the waterwheel manufacturer's contract.

Often, too, the tests reported are based on wheels which have been prepared especially for the test, having been fitted with roller or ball bearings, and having had many extraordinary precautions taken to reduce friction. The runners may have been made exceedingly close, the blades burnished to a glass finish, the edges of the blades made knife sharp, the guide vanes likewise polished, and all edges made as fine as possible so as to avoid any possibility of eddies. Such conditions would only last during the period of the test; and although a wheel may show exceedingly high efficiency under these ideal conditions, the same wheel when installed for practical purposes would show no such efficiency.

In a very large proportion of the tests recorded in catalogs and elsewhere, the speed of the wheel is not maintained constant, nor is it maintained at a constant percentage of the spouting velocity of the water, but under each gate condition the wheel is allowed to find its own best speed. Under most conditions the purchaser of a wheel desires his wheel to run at a constant speed under all conditions of load, hence, a test of this character means nothing to him, and such a test when shown to him is misleading. To be of any value, tests should be conducted for a certain percentage of the spouting velocity of the water, and this percentage should remain constant through the test, as it is frequently impossible to maintain the head constant during the test.

Different manufacturers rate their wheels under different conditions; that is to say, some rate the wheels under a percentage of the gate opening, and others under a percentage of the water discharged. A 50 per cent. gate opening does not mean 50 per cent. of the water flowing at full-gate opening, nor does it mean 50 per cent. of the power developed under full gate. The best way of rating a wheel is on the percentage of the water flowing under different conditions of gate openings; that is, the wheel should be rated at full gate or 100 per cent. discharge; 75 per cent. discharge, 50 per cent., 30 per cent., etc. Under these conditions the purchaser could readily compare wheels on the basis of the percentage of water discharged, as compared to full gate, which is a constant factor for all wheels.

It is frequently desired to know what the speed of a certain wheel will be under conditions of a certain head when data are at hand for some other head only. As all wheels run at a speed which is practically fixed by the spouting velocity of the water, it is apparent that the speed will vary directly as the square root of the head; hence, knowing the speed at a given head, a constant can be derived by dividing this speed by the square root of the head. To determine the speed at any

other head, it is merely necessary to multiply this constant by the square root of the head in question. It is also frequently desired to know what the power of a wheel will be at some different head. This is also readily obtained from the fact that the power depends upon the head which is acting on the wheel, and the quantity of water which will flow through the wheel at that head; hence, the power is in proportion to the three-halves power of the head.

This being the case, the power at any head may be divided by the three-halves power of this head, giving a constant which, if multiplied by the three-halves power of any other head, will give the horsepower at that head. It is possible to determine with fair result the speed of a wheel of a certain diameter at any head, from the fact that the average American reaction runner operates at a speed which approximates 65 per cent. of the spouting velocity of the water, and the spouting velocity of the water is approximately

$$0.95\sqrt{2gH}$$

in which g has its usual significance of acceleration due to gravity and H is the head acting on the wheel.

The maximum theoretical efficiency of the present reaction type of waterwheel will not exceed 97 per cent. and frequently falls short of this. The loss due to the energy in the water leaving the wheel will vary from 1 to 5 per cent., although in some cases it may exceed this. The loss in the guides due to friction and eddies will vary from 1 to 10 per cent. as will the loss in the wheel blades, particularly those of the warped type having exceedingly deep buckets, where the water flows inward, downward and outward. No matter how smooth the castings may be made, there is sure to be considerable friction and considerable eddy loss in a wheel of this character. The leakage loss depends very largely on the size of the wheel; it might readily amount to anything from 3 or 4 per cent. up to 10 or 12 per cent., and the friction loss in the bearings is an item of wide variation although it usually amounts to from 2 to 5 per cent. in good wheels.

Let us then take a wheel having a theoretical efficiency of 97 per cent. and subtract from this the various items of loss. If all of the losses are assumed to be the minimum as quoted, the wheel efficiency will not exceed 89 per cent.; if the losses are average, the efficiency is about 79 per cent. That this latter is nearer to the actual conditions that exist than the former is shown by the fact that nearly all wheel manufacturers list their wheels at 80 per cent. efficiency.

It might be worth while to call attention here to the fact that these losses are those of the moderate-head reaction type, and that the leakage losses and the losses in the buckets and guides may be considerably smaller than the average here quoted in the shorter-bucket, radial, inward-flow wheels of the Francis or modified Francis type, and also that the leakage loss does not exist in impulse wheels.

It is evident, therefore, that anyone purchasing a waterwheel should look into the proposition carefully. When efficiencies of over 80 per cent. are guaranteed, particularly over wide ranges of load, the conditions under which these guarantees are made should be examined into and placed in the contract with a bonus and forfeiture clause in order to protect the purchaser. Care should be taken that the efficiencies are guaranteed under conditions of installation and not under those at some testing flume. The purchaser is interested only in what the wheel will do at his plant and under the conditions there; he has no interest at all in what the wheel can do under other conditions. The head should be that between the forebay and the tailrace, and the power should be that actually delivered by the wheel where it is to be attached to the machinery, so that all of the losses in the wheel installation are taken into account. Attention to these items will frequently save more or less discussion and hard feeling. It is also advisable to see that the type of wheel which is offered is suitable to the conditions under which it is to operate. The American type of wheel, having the long, deep buckets and a small diameter of runner, is not adapted to high heads, although it is frequently sold for such purposes. The buckets, being long and deep with a very marked curvature, cause friction and eddy-current loss.

Concrete for Machinery Foundations

By G. Wise

Owing to its many advantages, concrete is now almost universally used for machinery foundations. Such being the case, it is essential that the plant superintendent or engineer, who is occasionally called upon to install small foundations, be familiar with certain fundamental principles which insure the production of good concrete.

At the present time foundations for heavy machinery are almost exclusively made of concrete on account of its low cost, the availability of the materials that enter into its composition, and the ease with which it can be mixed and molded into irregular shapes and around foundation bolts. Concrete is particularly suitable for this purpose, as when completed the foundation is a solid mass; and as such it more successfully absorbs the vibrations of high-speed machinery than would a similar foundation built of brick or stone. Also on account of the plastic condition of the concrete, when put into place it conforms perfectly to any irregularity of the ground; this sustains the foundation and thus insures a perfect distribution of the load over the soil.

Concrete appeals particularly to the plant superintendent for use on occasional jobs because the necessary materials can easily be secured from local sources and the work done by labor already at hand. This, therefore, reduces the total cost to a little more than that of the materials. The information herein given is intended to be of assistance to those who occasionally use concrete in small amounts.

To most people the mixing of concrete seems to be a very simple process based upon empirical rules which have proved satisfactory by past experience. Only to a slight extent is this true, as years of study have shown that there are several fundamental principles in connection with the use of concrete, the understanding and application of which will insure satisfactory and consistent results and remove the element of chance which so often exists.

Materials

The materials commonly used for making concrete are cement, sand and crushed stone or gravel, the latter being above ¼ inch in diameter. The cement is the active constituent, the binder which serves to hold the concrete together; the sand and crushed stone, called by concrete experts the fine aggregate and the coarse aggregate, respectively, are the inert or inactive materials which serve not only to reduce the cost but also to increase the strength.

A pile of sand or broken stone does not consist of a solid mass of material, there being a void space between the various particles. The amount of this void space is usually stated as a percentage of the total volume and has an average value for sand of 40 per cent. and for crushed stone of 45 per cent.

The percentage of voids in the fine and coarse aggregates is the principal characteristic which determines their value in the concrete, and is the basis for the proportioning of the materials. This statement is based upon the principle that in a theoretically perfect concrete every particle of the fine aggregate must be coated with cement and every particle of the coarse aggregate with the cement-sand mortar; also, every void must be filled, the smaller grains fitting in between the larger ones, in order to have a dense and strong concrete. A small percentage of voids is therefore desirable, and to secure this condition the fine and coarse aggregates must consist of particles varying in size.

Portland cement of any standard brand may be considered reliable. It is best, however, to buy it from some reputable dealer who is familiar with it. One bag of cement has a net weight of 94 pounds and a volume of approximately one cubic foot.

The fine aggregate used for making concrete may be any sand which is hard, clean and coarse. A sharp sand, while otherwise satisfactory, contains a large percentage of voids and will not produce as strong a mortar as will a sand with rounded grains. Cement cannot adhere to dirty sand, so clean sand is a necessity. If the sand is otherwise suitable for use, washing with water will remove this impurity. As to size the sand should be well graded from coarse to fine with the former predominating, all material less than ¼ inch in size being classed as sand. Many sands used in making concrete and mortar consist of particles which are small and uniform in size; these sands not only require more cement but also more work in mixing in order to coat every grain with cement. The average weight of a cubic yard of sand is about 2700 pounds.

Crushed stone or gravel is the coarse aggregate generally used and for this purpose it should be hard, clean and well graded in size. The quality of the concrete is greatly influenced by the hardness of the coarse aggregate, the hardest producing the best concrete. Comparative tests show that the relative values of the different aggregates are in the following order: Trap, granite, gravel, marble, limestone, slag, sandstone, slate, shale, cinders.

The aggregate must be clean, as any coating of dirt will not permit direct contact with the cement and will thus lower the strength of the concrete; also a stone with a chalky surface cannot produce a good concrete. The crushed stone should be cubical in fracture as it then packs easily and more closely than does flat-grained material.

All pieces less than ¼ inch in size should be screened out and used as sand, and the remainder should be well graded in sizes up to 1¼ inches. If larger than 1¼ inches they are liable to separate from the mortar when pouring the concrete. In large masses of concrete the work may be strengthened and also cheapened by dropping into the mass of wet concrete, stones as large as can be handled by one man. The average weight of a cubic yard of crushed stone is about 2500 pounds.

The water used must be free from oil, acid, strong alkalies or vegetable matter.

Estimate of Materials

This is probably best illustrated by citing a particular case. Suppose that an inspection of the soil and the foundation plan shows that the volume of the required foundation is about 210 cubic feet or approximately 8 cubic yards. For machinery foundations a mixture of the materials in the proportion of one part by volume of cement, two parts by volume of fine aggregate and four parts by volume of coarse aggregate will be found satisfactory, this proportion being commonly written as a 1:2:4 mixture.

One cubic yard of concrete of this proportion will require: Cement, 5.84 bags; sand, 0.41 cubic yard; stone, 0.82 cubic yard; water, 26 gallons.

Considering a cubic yard of sand to weigh 2700 pounds and a cubic yard of stone to weigh 2500 pounds, this foundation of 8 cubic yards will require:

Cement, $8 \times 5.84 = 46.72$ bags.

Sand, $8 \times 0.41 = 3.28$ cubic yard, $\times$ 2700 = 8856 pounds.

Stone, $8 \times 0.82 = 6.56$ cubic yard, $\times$ 2500 = 16,400 pounds.

From the above, the finished concrete may be assumed to weigh approximately 150 pounds per cubic foot, which would make the total weight of this foundation about 31,500 pounds.

Mixing

In order to have a uniform concrete in accordance with the proportion previously decided upon it is best always to measure accurately the materials for each batch; for this purpose a 36 and 16 by 12-inch bottomless box with a capacity of 4 cubic feet will be found convenient. Also, the size of the batch should be such that it can be easily and quickly handled.

After the sand is measured, spread it evenly on a water-tight platform and then spread the cement over the sand. Mix the two thoroughly until the mass has a uniform color and then form a large crater for the reception of the water. Into this slowly pour the required amount of water and assist its absorption by slowly turning the material into the crater. Then thoroughly mix until the mass becomes a smooth mortar. Upon this mortar spread the measured amount of crushed stone or gravel, which has been previously wetted, and mix thoroughly until all the particles are coated with the mortar. If more water is needed add it from a sprinkling can. It will be noticed that the mass becomes more moist as the mixing progresses, which is an indication that the particles are being forced into closer contact.

Forms, Pouring and Finishing

For foundations below the surface of the ground no forms are needed except a templet to properly locate and hold the foundation bolts in position, as the concrete can be poured directly in a well made trench of the proper dimensions. In order to allow for adjustment of the foundation bolts it is well, before concreting, to surround these bolts by tin tubes. When the concrete has hardened, these tin tubes can be removed; and after the machine is placed, the holes can be filled with a thin cement mortar.

When above the ground, forms must be provided to hold the concrete until it hardens. These forms must be tight so that the cement mortar cannot run out and they must be strongly made and well tied together to withstand the side pressure of the wet concrete. The forms should be thoroughly wetted before the concrete is poured.

Immediately after the mixing is finished the concrete should be poured in the form and rammed or agitated in such a manner as to produce a dense mixture. In small jobs the work of placing the concrete should be carried on continuously until the job is completed; where this is not possible the old concrete should be well wetted before the new is added. The forms in work of this kind can be removed in from 24 to 72 hours, but after the removal of the forms the concrete should be wetted occasionally for a period of at least ten days.

The surface of the concrete after the removal of the forms will show the imprints of the wood. If this is objectionable it can be removed by bush-hammering the surface; or if a surface of exceptionally good appearance is desired the following method can be employed.

Secure screenings of gravel, crushed trap rock or granite that will pass a sieve of ⅜-inch mesh and be retained on a sieve of ¼-inch mesh. With this as the coarse aggregate make a concrete in the proportion 1:2:3 and use this as a facing mixture, placing it against the forms about 1½ inches thick, just before each batch of concrete is poured. Make only a small batch of this facing mixture and use when needed. As the facing mixture and the concrete are both of a wet consistency, they will readily unite and form a solid mass. This surface is finished by removing the forms as soon as the concrete has set and then, while the concrete is still friable, by washing with water and a stiff brush, rubbing it sufficiently to expose the aggregate of the facing mixture. This process removes all possibility of surface cracking and produces a surface resembling stone in texture.

The Watt Relics at South Kensington

By F. A. Halsey

A micrometer caliper, surface condenser, steam-engine indicator, trussed beams, gearing to replace the engine crank, models showing application of engine power, and several complete and operative engines are some of the relics that have been preserved with such intelligent care.

These form a striking demonstration of Watt's ability as a machinist, engineer and experimental investigator. The importance of his work cannot be overestimated.

To an American who realizes the small number of relics which we have of the pioneers in engineering and machine construction, nothing can be more gratifying than to witness the industry and care with which such things have been collected and preserved in England. Of all those whose work we would most wish to have thus cared for, James Watt easily heads the list, and it is precisely his work of which the greatest number of examples remain. It is impossible to overestimate the importance of his work, which constantly grows on one with study. Mr. Chubb has given an account of such things as are kept at Watt's old home and place of business at Soho, and this article will show a few of those which are on view at South Kensington Museum. The man who fails to feel the impulse to uncover his head when standing before these things, deserves expulsion from the fraternity of the engine room.

Two Complete Watt Engines

Of these exhibits, the most striking are two complete and perfect examples of engines as built by Watt. The first is illustrated in Fig. 1, which shows his first sun-and-planet engine built in 1788. Its cylinder is 17 inches diameter by 48-inch stroke, the mortise flywheel being 16 feet in diameter. It was nominally of 10 horsepower, but actually indicated 13¾ horsepower, figures which by their smallness are certainly striking in comparison with the size of the machine. It continued at work until 1858, its work being the driving of a metal-working shop of some sort.

The engine illustrates the natural process of transition from the pumping engines previously built by Watt, to engines for driving revolving shafts. The pumping engine, of course, had no shaft, the piston rod being connected to one end of the walking beam, while the pump rod was connected to the other, and the na-

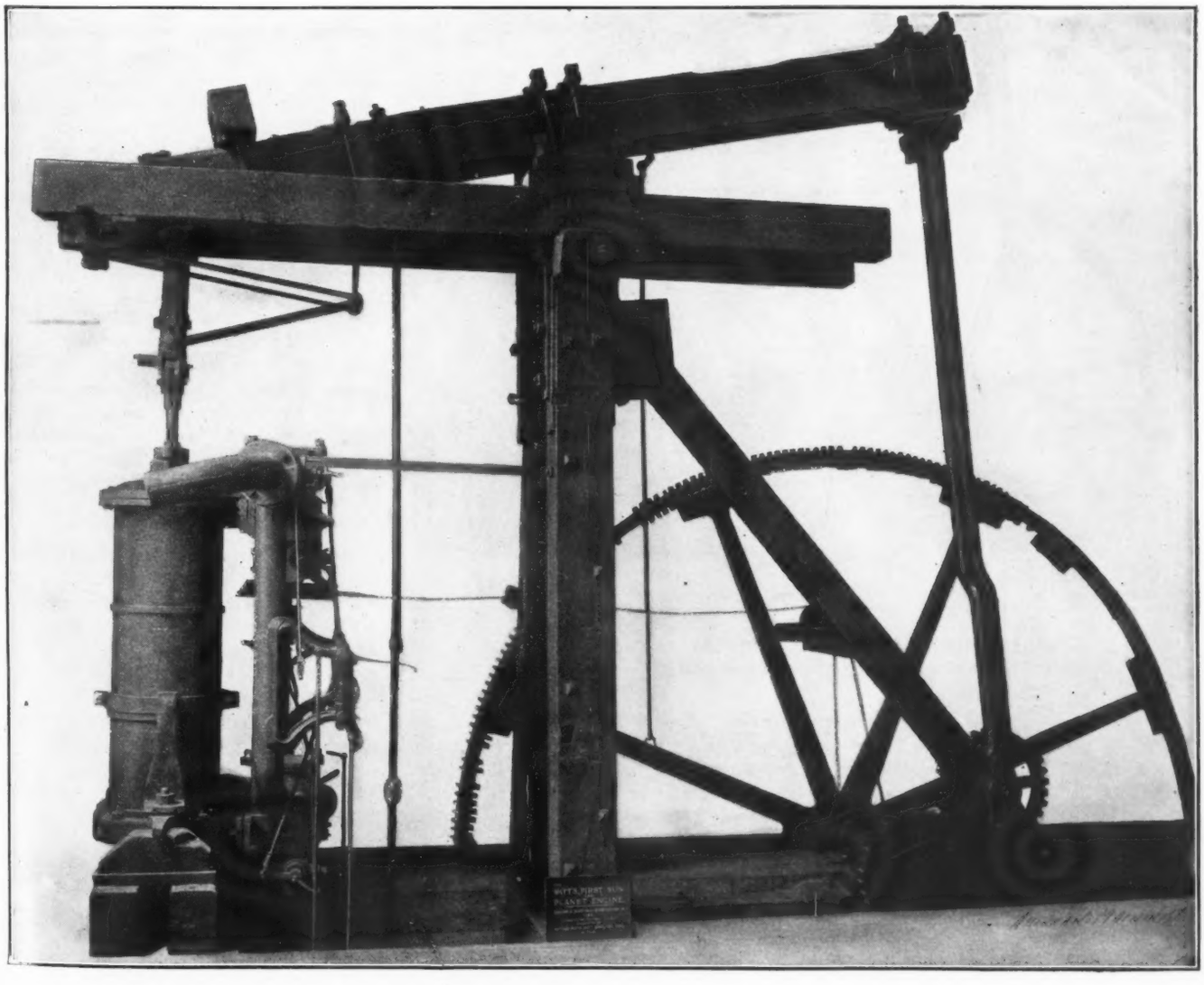


Fig. 1. James Watt's First Sun and Planet Engine—1788

tural method of actuating the valve gear was by a plug rod which hung from the beam, on which suitable tappets moved the valves at the ends of the stroke. In this engine we see precisely the same gear, the plug rod serving also as the air-pump rod, the driving of the valves by means of an eccentric being still unknown. This valve gear, as will be seen, is by no means simple, and the understanding of it in all of its details is not easy without turning over the engine, which is, of course, not practicable. It is, however, clear that the direct action of the tappet was to move the valve to the closed position where it was secured by a latch, the opposite valve being simultaneously opened by the releasing of its latch and the action of a weight. The valves are of the oscillating type, although the exact construction cannot be made out without removing the chest cover. Except for the reversed action, it would require no great stretch of the imagination to see in this an anticipation of the Corliss gear. Moreover, it is a principle of the patent office that reversal of a mechanism does not constitute invention. The governor will be seen behind the valve connections driven by a chain and pulleys. It acts upon a throttle valve of the disk type. We see also Watt's beautiful parallel motion.

Fig. 2 shows another engine in the same collection, which was erected in 1797 and continued in operation until 1885. It had originally a cylinder of 16 inches diameter by 48-inch stroke, but in 1806 the makers substituted a new cylinder of 19¼ inches diameter.

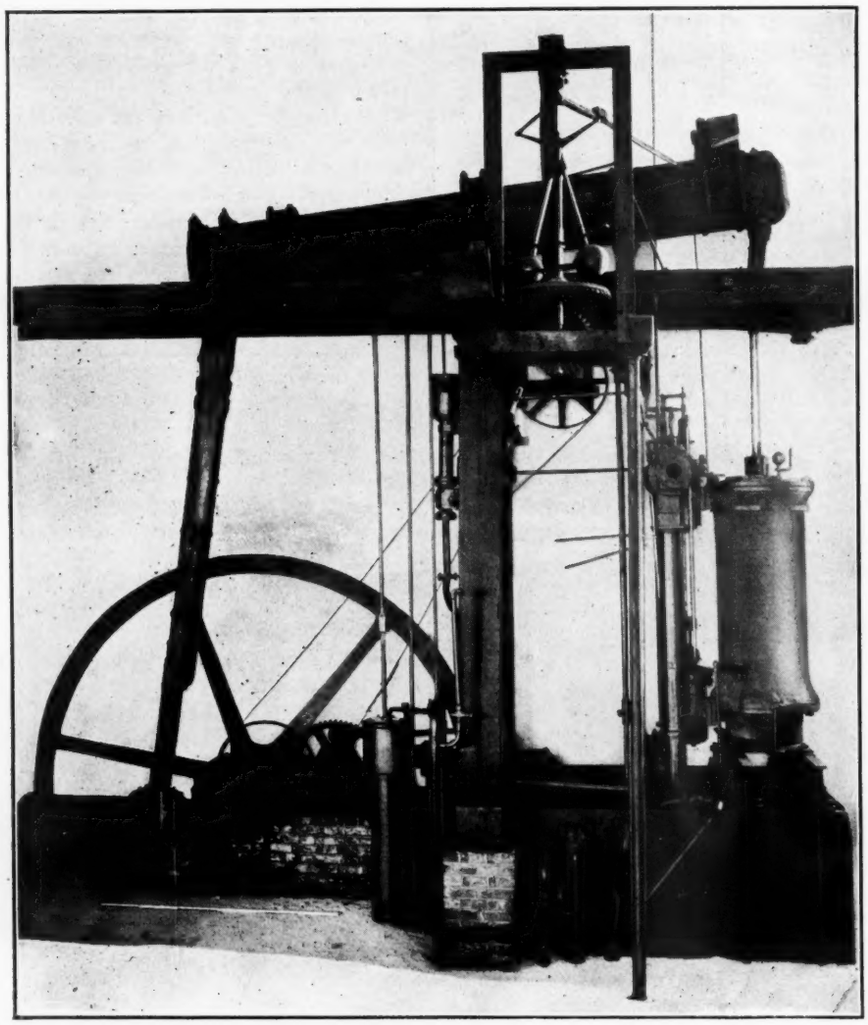


FIG. 2. ANOTHER SUN AND PLANET ENGINE SHOWING THE PROGRESS OF IMPROVEMENT—1797

THE PROGRESS OF IMPROVEMENT

In several respects this engine is a marked advance over the preceding one. The valves are driven by a crank motion obtained from a lay shaft geared to the main shaft in such manner as to reduce the speed one-half, this being necessary because with the sun-and-planet gear the shaft made two revolutions for each double stroke of the engine. The action of this crank was, of course, the same as that of an eccentric and, in view of the necessity for a lay shaft, it was a natural preliminary to the eccentric. In addition to this, the engine is fitted with a separate cut-off valve operated by a cam upon the lay shaft. This valve is located at the end of the steam pipe, one valve thus serving for both ends of the cylinder, the cam having two lobes. The connecting rod from the valve crankpin is made with a gab end, permitting it to be disengaged and the valves to be worked by a hand lever when starting the engine. The valves are of the poppet type, the steam and exhaust valve for each end of the cylinder being eccentric with one another and the stem of one passing through the hollow stem of the other.

In addition to these engines there are the main parts of a pumping engine erected in 1777, which, however, has not been photographed and which is so located as to make photographing too difficult for it to be undertaken. It antedates the parallel motion, having the horse-head-and-chain connection between the beam and the piston and pump rods.

Regarding the long terms of service of these engines, it should be said that they have been exceeded by other Watt engines, one of which, believed to be the first sold by Boulton & Watt, a pumping engine erected in 1776, continued at regular work for a period of 116 years, and was occasionally used for six years more. It is still preserved at Ocker Hill, Tipton, in working condition. It is much larger than the engines here shown, having a cylinder 33 inches diameter by 84-inch stroke, and was originally built to assist a water wheel in dry weather by pumping water from the tailrace back to the headrace. Long after the introduction of the rotative engine, this method of driving continued in use for textile mills, because of the more uniform speed when obtained from water wheels. The slide valve was invented by William Murdock, Watt's superintendent, and was employed in some cases, although Watt preferred the poppet.

WATT'S FIRST CONDENSER

As a classical relic of Watt's work, the palm must be given to Fig. 3, which shows the original experimental model of a separate condenser. It dates from 1765 and was undoubtedly made by Watt's own hand. It will be recalled that prior to Watt's time the steam was condensed within the cylinder by the aid of water injected therein, and this model was made in order to test his first and most fundamental invention—the separate condenser. It consists of a steam-jacketed cylinder, 1.4 inches diameter, fitted with a hemp-packed piston. From the piston a rod passes downward through a stuffing box and terminates in a hook, from which a weight of 18 pounds, indicating a vacuum of 12 pounds, was suspended. Connected to the upper end of the cylinder is a vertical pipe—

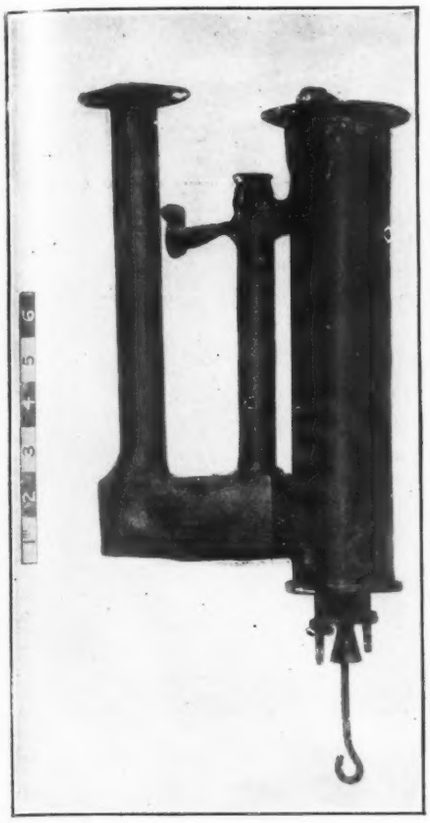


FIG. 3. ORIGINAL MODEL OF A SEPARATE CONDENSER

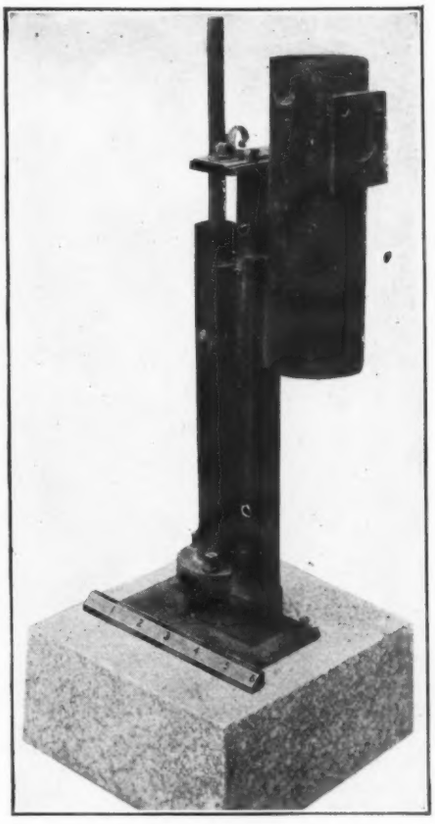


FIG. 4. ORIGINAL MODEL OF A SURFACE CONDENSER

the condenser—closed at the top and connecting below with a metal box from the further side of which passes upward a vertical tube which forms the air-pump barrel.

Most curiously, the model is now assembled in an unworkable manner, the first connection of the condenser being with the steam jacket, which in turn communicates with the lower end of the cylinder. There exists a proper connection with the upper end of the cylinder, which has been soldered over, and other features of the model show that the condenser connection must have been originally by this hole. It is surmised that after his experiments and before his patent was secured, Watt may have made this change in order to mislead anyone into whose hands the model might fall.

It should be noted, moreover, that as the model stands it is not a jet condenser, there being no opening for water into the condenser. The description states that the condenser and air pump were submerged in a tank of water, the condenser being thus of the surface type. At the same time, had there been an opening for water through the cover, it would have been easy for Watt to have removed this cover and replaced it with another in case he was bent on deceiving others. On the other hand, for the purpose of experiment, the cold surface may have given sufficient capacity without the jet.

THE FIRST SURFACE CONDENSER

Fig. 4 shows a model which is only second in interest to the one already shown. It bears a label reading "Original Model of a Surface Condenser," and was probably made shortly after the previous one, and if the previous one was originally a surface condenser this one represents a little more than an increase of surface. It contains an excellent condenser with 140 small tubes soldered into a metal tube plate at each end—the cooling water passing through the tubes and the steam to be condensed being admitted to the shell and outside the tubes.

The pipe next the condenser connects near its top with the condenser and at its bottom with the barrel of the air pump, which has a solid piston. The valves are fitted to the intermediate pipe—the delivery valve at the top of the pipe and the suction valve at its junction with the condenser—the actual pumping being thus done by the rising and falling water column—a superior construction, it will be remarked, because of its eliminating clearance.

Watt was obliged to abandon this con-

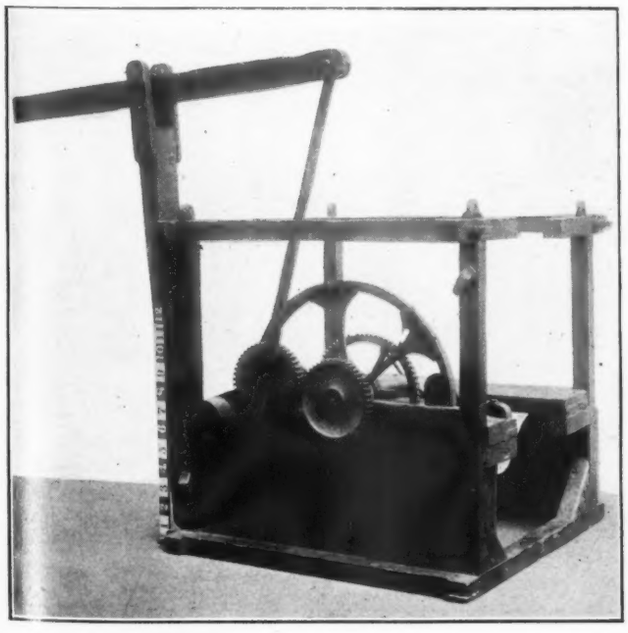


FIG. 5. WORKING MODEL OF A SUN AND PLANET GEAR

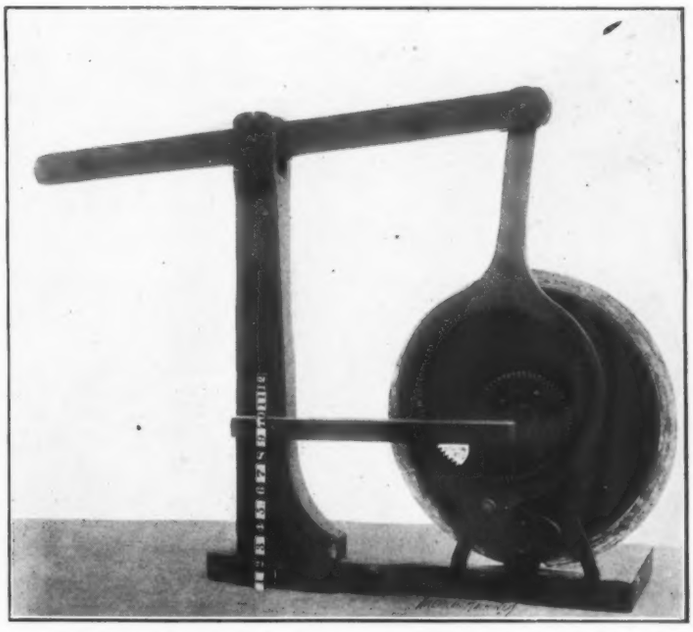


FIG. 6. WORKING MODEL OF AN INTERNAL GEAR CONNECTING ROD

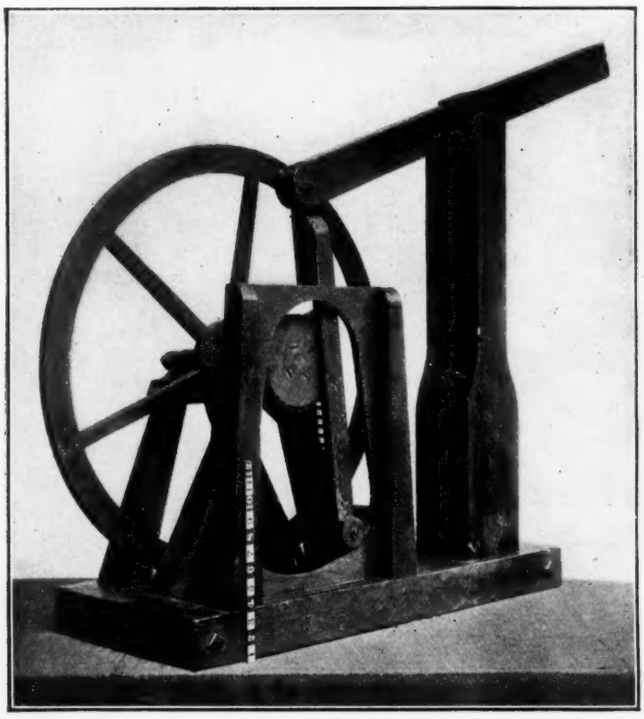


FIG. 7. MODEL OF A LADDER CONNECTING ROD

FIG. 8. WATT'S PLAN FOR DRIVING A FLOUR MILL

denser, because of the difficulty of keeping it tight—a difficulty which was not surmounted until long after his time.

STRANGE SUBSTITUTES FOR THE CRANK

Nothing seems so strange in connection with Watt's engine as the sun-and-planet gearing. The explanation of this construction lies in the fact that in the application of the crank he was forestalled by a patent taken out just in time to prevent his using it. Watt regarded the patent as a piece of piracy and refused to make terms with the patentee. In order to avoid this, he was forced to invent a substitute, and the sun and planet gear was the result. That the task was not an easy one is shown by the models of other devices, which he made before adopting this one. He was much given to model making, by the way, as were most of the old masters, and the museum contains a large number of examples other than those shown here, and of scarcely less interest. Among those included is Fig. 5, which is a working model of the sun-and-planet gear. A first cousin to this is found in Fig. 6, which is a model of an internal-gear connecting rod,* while perhaps the strang-

*The lack of roundness of the internal gear is due to the shrinkage of the material, which is wood.

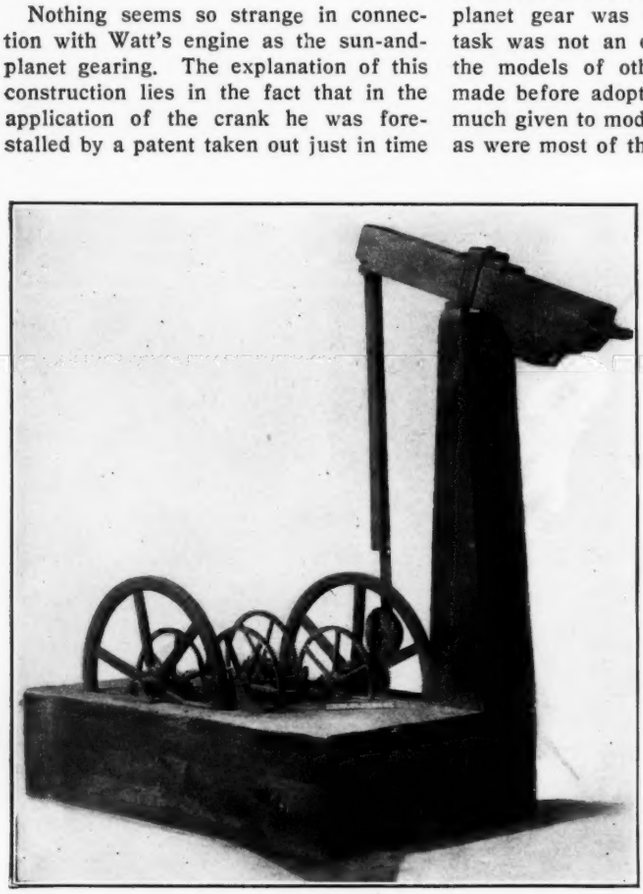


FIG. 9. WATT'S PLAN FOR DRIVING A ROLLING MILL

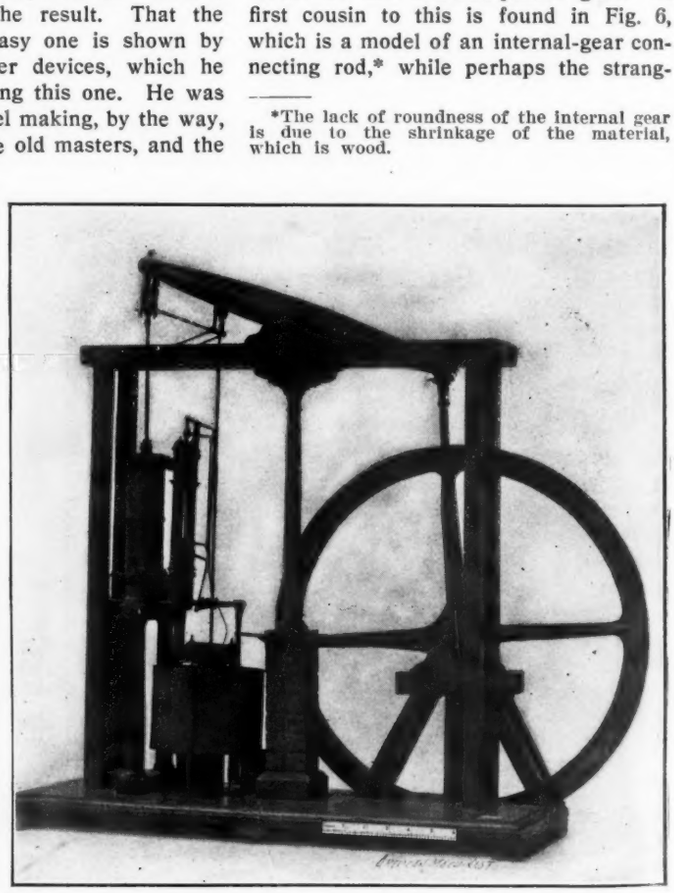


FIG. 10. A WATT MODEL ENGINE

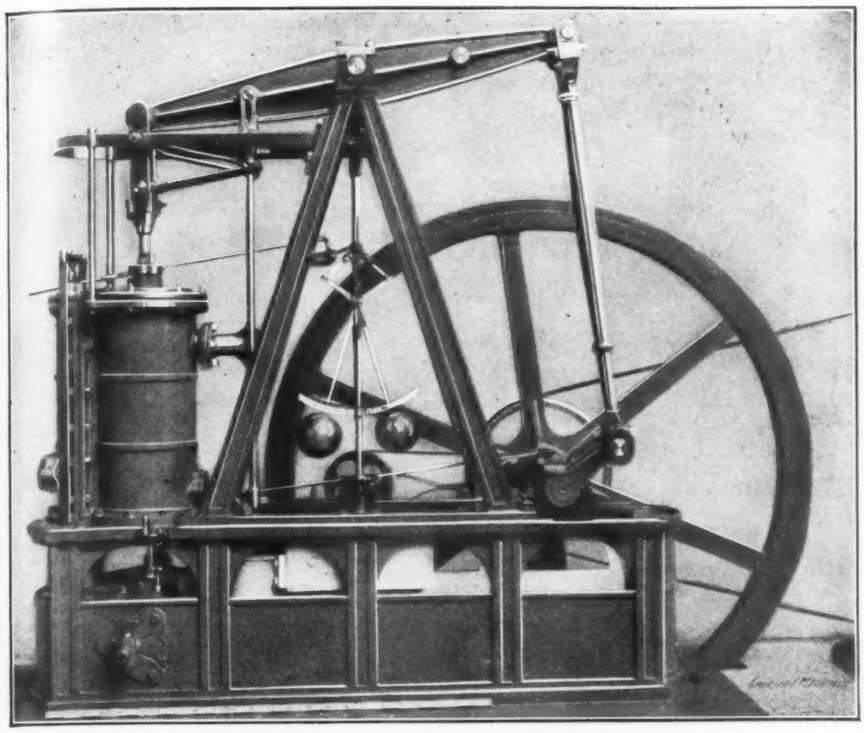


FIG. 11. ANOTHER MODEL ENGINE LEFT BY WATT

est of all is Fig. 7, which shows a "ladder-connecting rod," than which nothing could more strikingly illustrate the straits to which Watt was put. The main shaft ends in a gear, while the connecting rod carries at its end a long rack composed of rungs like a ladder and capable of acting on either side of the gear. At the lower end of the connecting rod is a roller which works in a large opening of special form in a fixed guide plate, which keeps the rack in mesh with the gear. At the conclusion of the downward stroke, when the last rung is in mesh, the lower end of the rod swings to the other side of the gear, being guided and maintained in mesh by the guide plate, the reverse movement taking place at the end of the upward stroke. Still other devices for the same purpose are shown in model form. In spite of its unpromising features, the sun and planet gear was continued in regular use until about 1800, when the embarrassing patent ran out.

DEMONSTRATION MODELS

It must be remembered that Watt was engaged in the introduction of the greatest innovation that engineering has ever seen. The driving of a revolving shaft by means of steam power originated with him and he had the problem before him of convincing owners of mills that his engine would form a successful substitute for water and horsepower. In order to demonstrate his ideas, he had recourse to many models, and among these is one shown in Fig. 8, to illustrate the application of his invention to the driving of flour mills, in which service, in fact, the engine found some of its earliest applications.

The model shows the method of driving a mill having six runs of stones. The connecting rod has two sun-and-planet motions, one on each side, each of which connects to a driving shaft carrying a flywheel. A bevel gear on each flywheel shaft meshes with a second bevel on a vertical shaft, which also carries a spur wheel meshing with three pinions, one on each of the mill spindles.

Fig. 9 shows a somewhat similar model of a rolling mill, and others showing forge hammers and other machinery driven by the engine are shown at the museum.

MODELS OF COMPLETE ENGINES

While many of Watt's models had a utilitarian purpose, he also made others for his personal gratification, and, whatever one may think of models in general, he cannot be other than thankful that Watt, and for that matter others, thus left records of their work. Among several of this kind that still exist is the one shown in Fig. 10, which was probably made about the year 1800. It is of far better workmanship than the demonstrating models, being, except for the frame, of metal. Like many other models throughout the museum, a compressed-air system is connected to its own cylinder, by which it is kept constantly in motion. The valves are of the poppet type and of the same construction as in the second large engine already described, and are driven by an eccentric working through a tappet gear. It will be seen that the sun-and-planet gear has disappeared. The steam cylinder of this model is 1⅝ inches diameter by 4½-inch stroke.

The gem of the collection from the modelmaker's standpoint is shown in Fig. 11, which was bequeathed by Watt to

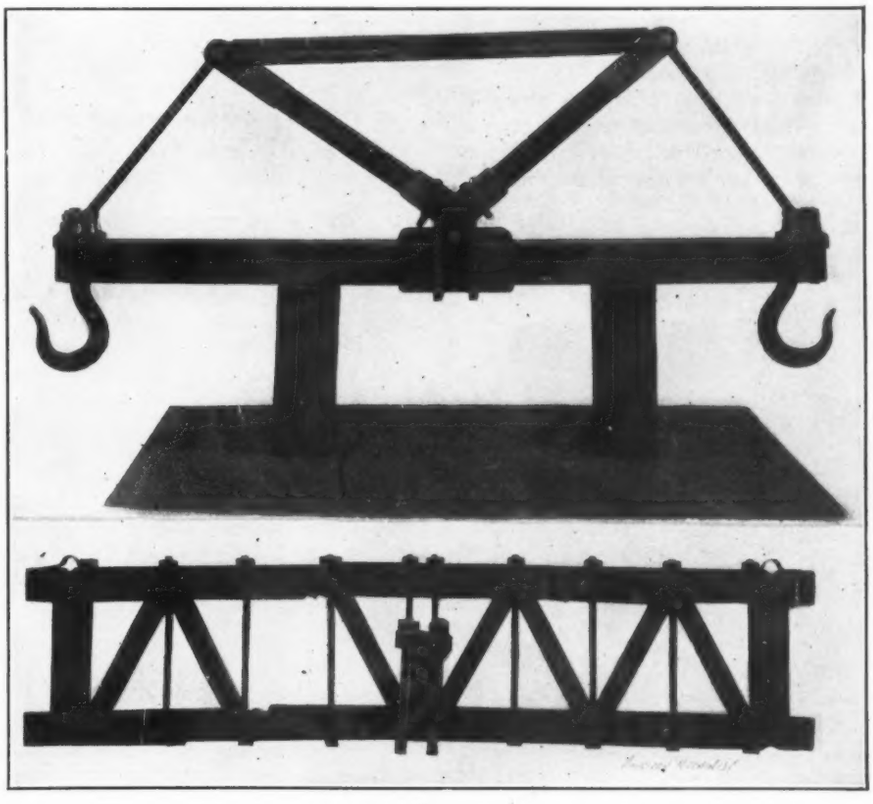


FIG. 12. TEST MODELS OF TRUSSED WORKING BEAMS

John Kennedy, of Manchester. It fairly represents the culmination of Watt's work and as a piece of model making it would be creditable to any model maker today. I am not informed of the size of the cylinder, but the bed plate measures about 3 feet in length overall. Unlike the last model shown and the larger engines, this one is fitted with a slide valve of the long "D" form, which is driven by an eccentric. The cylinder is steam jacketed and the engine is fitted with Watt's governor. The frame, including the bed plate, is of iron and of almost ideal form. The engine as here shown, remained substantially the standard construction for many years. The illustrations of "the steam engine," in many of our dictionaries and other books of reference might almost have been taken from this model. Like the last model shown, this one is kept in constant motion by means of compressed air turned into its own cylinder. By the belt shown it drives a modern sectional model, showing the action of valves and piston.

More Experimental Models

The condenser models will illustrate the well known fact that Watt was an experimental investigator, and the next illustration, Fig. 12, will show the same fact in a very different field of work. There is evidence that he had trouble in connection with the walking beams of his engines, and this illustration shows models of trussed beams which were made in order to determine the proper proportions of such beams. One of the models is plainly fitted for attaching test weights, while the other has been tested to destruction. It seems curious, by the way, that while Watt's earliest pumping engines were fitted with trussed beams, the beams of the mill engines which are shown were constructed of nothing but a single stick of timber.

Fig. 13. A Watt Indicator

An Old Steam Engine Indicator

The steam engineer of today will look with a sympathetic eye upon Fig. 13, which represents a steam-engine indicator as used during Watt's time. The actual date of the construction of this instrument is unknown, but it was the property of Watt's agents in Manchester.

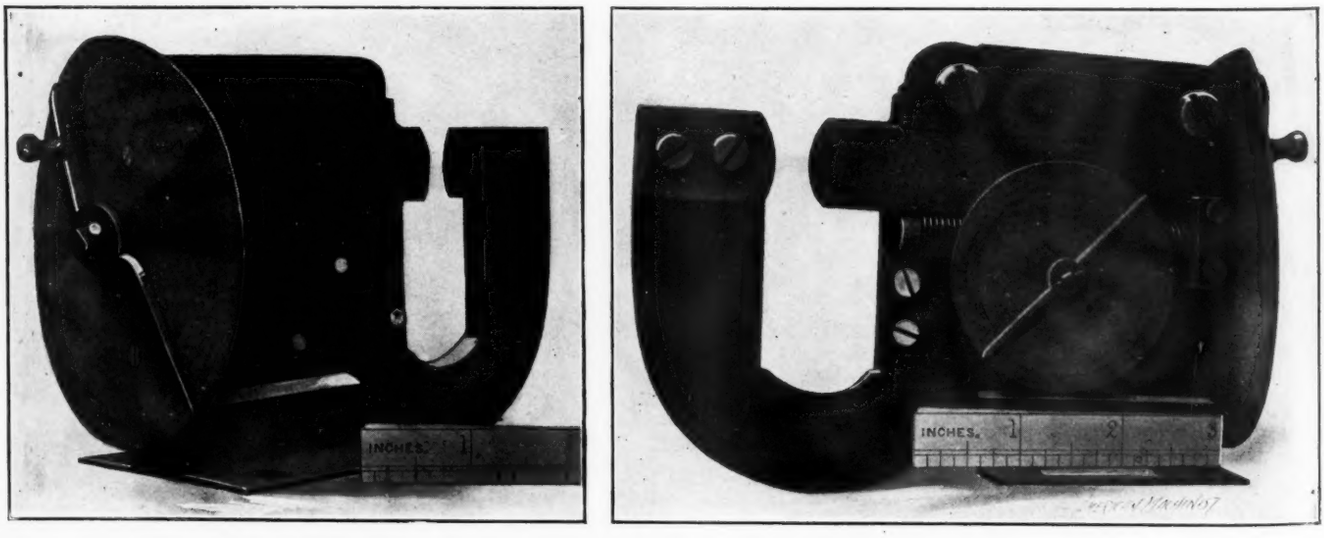


Fig. 14. Watt's Micrometer

it still carries a card which was taken in 1840, by Prof. E. Cowper. The instrument has a brass cylinder 1.13 inches diameter (1-square inch area).

The Father of Micrometers

If the last illustration is of prime interest to the steam engineer, the next and concluding one will be no less so to the working mechanic, for it illustrates a micrometer made by Watt. It has the regulation screw construction, although there is no nut. The screw has no endwise movement and the moving bar is fitted with teeth like inclined rack teeth, which engage the screw. The dial is stationary, the screw being turned by means of the bar which crosses the dial. Whole revolutions are counted by the index on the smaller dial, this index being turned by means of a small worm wheel, which meshes with the screw. The screw has 18 threads per inch, while the dial has 50 main divisions, which are subdivided into halves. The main divisions thus read to the 1/900 of an inch, while the subdivisions read to the 1/1800 part.

The Hudson Terminal Buildings*

By W. F. West

Two mammoth buildings in New York City which contain 4000 offices and accommodate 9000 people. During the warm months current for light and power is furnished by the Jersey City power house of the Hudson & Manhattan Railroad Company at a cost of less than one-half cent per kilowatt-hour. During the cold months, when the steam-heating system is in service, the plant at the buildings furnishes the current for even less than this cost.

The Hudson and Manhattan Railroad Company operates trains through tunnels which connect New York City with about all of the railroad terminals on the New Jersey side of the Hudson river, as well as the electric car line which approach the New Jersey shores. In the downtown section of New York City, the system terminates in two mammoth office structures occupying two whole city blocks, bounded east and west by Church and Washington streets, and north and south by Fulton, Dey and Cortlandt streets. The buildings extend 22 stories above the sidewalk and four below.

In these buildings almost any conceivable thing from a railroad or steamship to tacks and birdseed may be bought or sold. Stores fronting on street, concourse and arcade, are occupied by druggists, automobile agents, jewelers, clothiers, hardware dealers, confectioners, butchers, fruiterers and florists. One of the buildings contains a bank.

The buildings contain the equivalent of 4000 offices, which are lighted on dark days by the equivalent of 30,000 forty-watt, 32-candlepower Tungsten lamps. There are 39 Otis traction passenger elevators. Of these, 22 are expresses, their first stop being at the eleventh floor. In addition to these, there are seven hydraulic elevators for baggage, etc., which are located below the street level. The elevators handle about 40,000 people in and out, per day. The buildings contain about 9000 occupants at present; they are about 87 per cent. occupied. About 50,000 people visit these buildings per day, including the stores. A total of about 120,000 people visit the buildings per day, including the concourse floor; of this number about 70,000 are passengers on the road. The road, according to the records, carried an average of 85,846 passengers per day during the month of August, 1909, and an average of 141,871 passengers during the month of March, 1910. This shows an increase in traffic of about 65 per cent. in seven months. The running time between Jersey City and the Hudson Terminal buildings is three minutes; between Hoboken, N. J., by way of Jersey City to the Hudson Terminal buildings it is ten minutes.

*Abstract of paper read before New York No. 24 N. A. S. E. (Phœnix Association).

The power house for operating the electric trains is situated in Jersey City. This location affords considerable advantage, particularly in the cost of coal, as it is obtained direct from the mines. This eliminates the cost of transferring it across the river and trucking. The plant is equipped with Babcock & Wilcox boilers, Curtis turbines and General Electric generators. During the warmer season when little or no steam is required for heating, the current for lighting the buildings is obtained from the Jersey City power house. The 11,000-volt alternating current furnished by the power house is converted in an electrical substation at the building to 240 volts direct current for use in the building.

The steam-electric plant for the buildings contains 1500 horsepower of Babcock & Wilcox boilers, fitted with McClave dumping grates, having about 29 per cent. of air space. No. 3 Buckwheat coal, commonly known as barley, is burned. The feed water is put through a Ward feed-water filter and a Wainwright heater. The boilers are fed by steam-driven Worthington or electrically driven Dean pumps, or by 2½-inch Metropolitan injectors. The generating equipment consists of two 400 horsepower tandem-compound noncondensing Rice & Sargent Corliss engines direct connected to 300-kilowatt double-voltage 120- and 240-volt direct-current Western Electric generators. The plant also contains a 144-cell storage battery, with a capacity of 2000 amperes for one hour.

The auxiliaries are as follows: Two steam-driven Worthington pumps and one electrically driven Blake pump for pumping water from the Loomis & Manning filters to the house-service tanks on the roof. One steam and one electrically driven Clayton air compressor for supplying air to six Ansonia sewage ejectors. Two vacuum pumps for the vacuum-cleaning system, two small electrically driven Crocker Wheeler air compressors for pumping air into the hydraulic-elevator tank at a pressure of 300 pounds per square inch. Two Laidlaw-Dunn-Gordon air compressors driven by Westinghouse motors for furnishing compressed air to the road in emergency. Three Dean triplex pumps driven by General Electric motors for the seven hydraulic elevators. Two fresh-air fans driven by General Electric motors, and two exhaust fans driven by Northern Electric motors. One vacuum pump built by the American Steam Pump Company, for the vacuum-heating system. One 80-ton Carbondale refrigerating system served by steam and electrically driven ammonia pumps and electrically driven brine pumps. Brine is carried at zero Fahrenheit and is pumped from the basement to the top floor, 26 stories, under a pressure of 215 pounds per square inch. There are 61 refrigerator boxes throughout both buildings to which brine is furnished.

The heating system contains 140,000 square feet of radiation which takes from 1400 to 1500 boiler horsepower per hour on a cold day. At this rate 60 tons of coal are required per day to heat both buildings. The average evaporation secured is 7.9 pounds of water from and at 212 degrees per pound of coal.

As the capacity of the Jersey City power house is quite large for the requirements of the road at present, and can furnish current for the buildings easily, the question is, which plant is to furnish the current for the buildings? The answer is, the one that can do it the cheaper. The next question is, how cheap can the power house furnish current to the buildings, and not how cheap

can the power house furnish current to the road? The road is another proposition. The answer is 3.5 mills, or 0.35 of a cent per kilowatt-hour. This figure was obtained from the additional amount of money which it cost the power house to generate the extra current minus the cost of labor to operate that part of the electric equipment in the Hudson Terminal buildings which could be dispensed with. This figure may seem impossible, but it is not necessary to run another unit to supply the load, which averages from 14,000 to 17,000 kilowatt-hours per day. The only additional cost is that of the extra coal, the handling of same, and a little extra in the way of supplies. This extra load on the power house helps to steady the machines serving the road, the requirements of which fluctuate considerably. The figure for the plant at the buildings is too high in the summer time to think of operating the generating equipment. It is 7.5 mills per kilowatt-hour. This figure is obtained by putting the cost of the auxiliaries where they belong. For instance, in the summer time, with the electric plant shut down, the only expense is that of the auxiliaries, the refrigerating plant and the steam for the kitchens. For an additional sum of $95 to $100 per day the electric plant can be run and from 13,000 to 14,000 kilowatt-hours per day can be generated. But even this low cost is too high to warrant the use of the generating equipment.

In the cold season, as long as the buildings require all of the exhaust steam for heat, the generating equipment can be operated for $21.11 per day, regardless of the amount of current generated. This sum covers extra labor and supplies, such as oil, waste and packing, and three-quarters of a ton of coal. This amount of coal is required to keep the cylinders hot or to evaporate 13,400 pounds of water from and at 212 degrees, the amount of water which is lost from the receivers and muffler tanks per day. This does not mean that the engines do not take 22 pounds of water per horsepower per hour, but it does mean that with a vacuum in the heating-system return line, the water that passes through the engines is in the form of steam and remains steam practically until it leaves the radiators. In other words, to all practical purposes, after passing through the cylinders, it is just as good at one-quarter to one-half pound pressure as is live steam reduced to one-quarter to one-half pound pressure through reducing valves. Reducing valves regulate the pressure in the heating main. When the electric plant is operated, the reducing valves let in enough live steam to the heating system to met the requirements. The more load on the engines the more live steam the valves shut off or *vice versa.* Hence, the more kilowatts generated, the cheaper they are. As there is not enough load for both of the engines through the night, the storage battery is charged at night and discharged during the day.

The minute the atmospheric relief valve, which is set for 1¼ pounds pressure, opens, it affects the cost of the current, for then the amount of the coal and the labor it took to produce the steam that goes out at the roof must be changed against the kilowatts. This is how the cost of the current is figured and as soon as the cost goes to 0.0035 dollar per kilowatt-hour, the electric plant is shut down for the summer.

Construction of Carroll's Gas Engine

In a recent issue we said that a search of the patent records showed that John E. Carroll, who proposes to run the industries of the country with a soda-water bottle, had no patents, excepting one upon an insulated pipe and a freak motor boat. Our search was of the United States patent records. We have since learned that he holds an English and a Chinese patent for "Motive Power Apparatus" which afford a glimpse into the supposed *modus operandi.*

The British patent office drawings of Carrol's carbonic acid engine, which are presented in this article show how impractical and absurd are the inventor's claims.

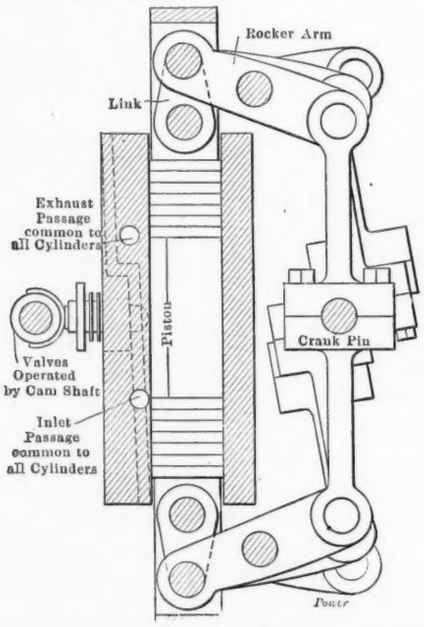


FIG. 1. SECTION THROUGH CYLINDER

Fig. 3 is an elevation of the engine, and Fig. 1, a section through one of the cylinders. The engine has three cylinders, each containing two pistons which are forced in opposite directions by the admission of carbonic-acid gas. Each piston is connected through a link, rocker arm and connecting rod to the crank shaft. The six cranks are set at different angles to equalize the torque. The valves are controlled by a cam shaft operated through gearing from the main shaft.

The exhaust is led into an exhaust or vacuum tank, which is shown in Fig. 4. This is the mysterious "regenerator," and the following description is taken from that in the patent record: "The exhaust pipe leads directly into the inner chamber *A*, adapted to hold a definite quantity of gas. Space *B* is a vacuum surrounding chamber *A*. *C* is a gas chamber connected with *A;* this is also inclosed by a second vacuum compartment *D*, so that when the gas enters *C* there is no interchange of heat by reason of the insulated walls of the vacuum chamber. Additional gas chamber *E* and vacuum chamber *F* are provided, so that when the gas eventually reaches *E* it has passed through all the gas chambers and around the numerous surrounding vacuums at various stages and is then in a *completely liquefied state, owing to the expansion it has undergone.*

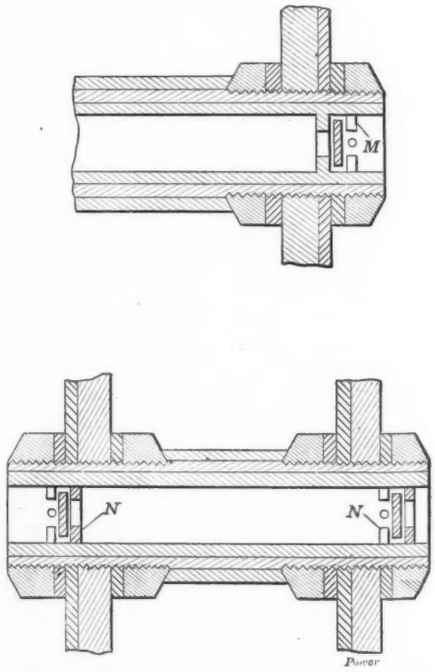


FIG. 2. CHECK VALVES IN EXHAUST AND OUTLET PIPES

The exhaust pipe is provided with a check valve shown at *M*, Fig. 2, and the outlet pipes from the various gas chambers contain check valves as shown at *N*, which allow the gas to pass outward. The outlet valves are of *progressively increasing resistance in order to compensate for the increase in pressure of the gas as it passes from one chamber to another.*

The liquid gas, after leaving the exhaust tank, is conducted to a charging tank, shown at *T*, Fig. 4, finding its way through a body of petroleum, represented by *P*. *The liquefied gas, being heavier than the oil, drops below it and then oozes through the oil* into the body of the tank in a gaseous state under considerable pressure, any water that may have been in the gas remaining under the oil. As the quantity and pressure of the gas in the charging tank increase, the supply from the exhaust and liquefying tank ceases until the gas is liberated for use.

At *S* in the charging tank is located a cage containing salt. The gas, after leaving the oil, passes through the salt, which extracts all moisture and renders the gas anhydrous. The gas is then conducted to the engine."

Mr. Carroll seems to have taken great liberties with the laws of nature, making them assume all sorts of forms and shapes to suit his purpose. The "law for the expansion of gases" has been turned "upside down" and taken the form that a gas at a constant temperature will increase in pressure with an increase in volume. Also through the valves the gas is made to flow against pressure. Further, we should like to see carbonic acid gas liquefied by expansion alone. The absurdity of the whole scheme is evident, at a glance, to anyone at all familiar with the fundamental laws of physics, and the efforts to place such a device upon the market is, to say the least, amusing.

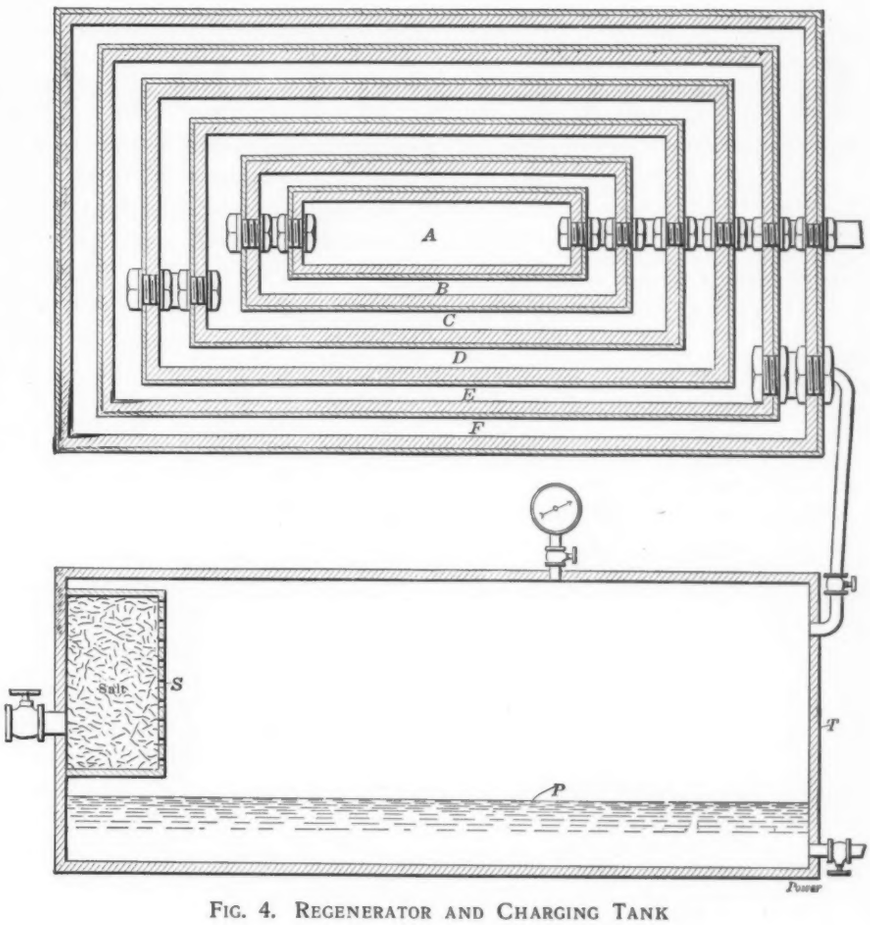


FIG. 4. REGENERATOR AND CHARGING TANK

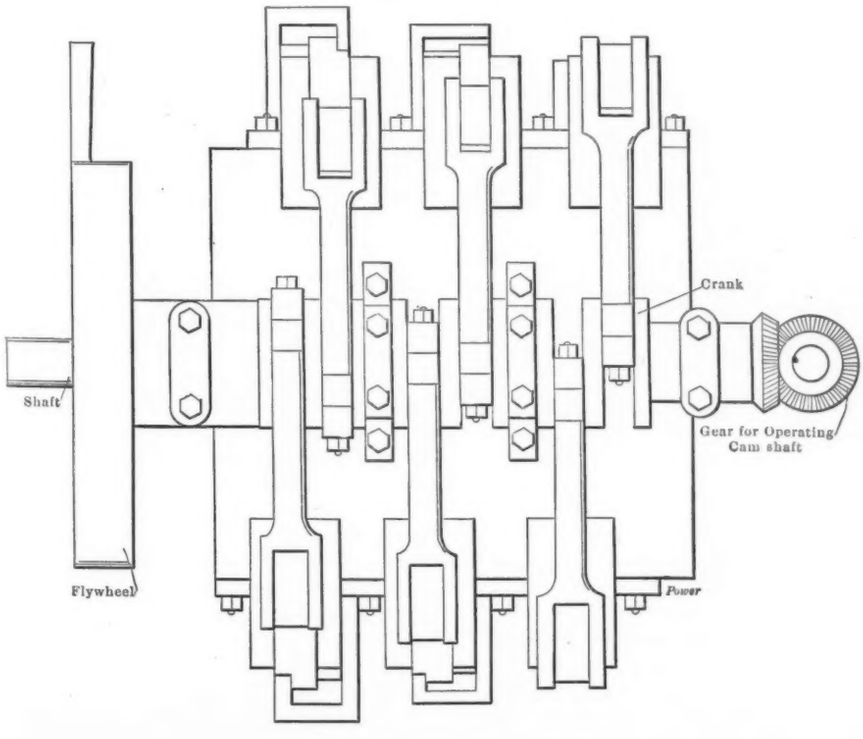


FIG. 3. SIDE ELEVATION OF ENGINE

Lignite for Central Station Fuel

Brown coal or lignite, the production of which in Germany now exceeds 60,000,000 tons per annum, is to be used on a large scale in connection with the supply of electricity to the city of Cologne. According to an agreement which has been concluded between the Municipal Council and the Rhenish company for lignite mining and briquet manufacture, the latter has undertaken to supply high-pressure three-phase current to the city in sufficient quantity to fulfil all purposes, beginning April 1, 1912. The present municipal works and those of districts to be incorporated can be continued and improved by the city, which is also at liberty to close them either wholly or partly and obtain the entire supply from the company. The agreement is for a period of 30 years. The charges will be according to a sliding scale of maximum rates which cannot be increased, but which are susceptible of reduction if the cost of production is lowered by the introduction of new inventions during the period of the agreement.—*Exchange.*

Electrical Department

Primer of Electricity

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

Brush Contact Resistance

Besides passing through the resistance of the armature winding, the armature current must pass between the brush faces and the commutator surface, and through the metal of the commutator bars. It is not practicable to figure the loss due to the resistance of the commutator bars, and this is so small that it is not worth figuring, if the commutator has been well proportioned. The loss at the brush faces, however, is considerable.

On all except a few special types of dynamos and motors the brushes are made of carbon, for reasons which will be explained in a future lesson. Now, as explained in one of the early lessons, the resistance of carbon varies very much with changes in its temperature, the resistance *decreasing* as the temperature increases. This behavior affects the resistance of the contact between the brush and the commutator somewhat as though the current were passing through carbon entirely; that is, the more current passes between the brush and the commutator, the lower is the resistance of contact, due to the heating of the carbon by the increased current. This decrease in resistance as the current increases has the advantage of preventing the loss due to the contact resistance from increasing as rapidly, with increasing current, as it does in the armature winding and other electrical circuits. That is, the voltage drop at the brush faces does not increase in the same proportion as the current, but very much slower—in fact, it is almost constant, with a certain quality of carbon in the brush and a certain range of current density at the brush face (the current density is the number of amperes passing between the brush and the commutator per square inch of brush-face area).

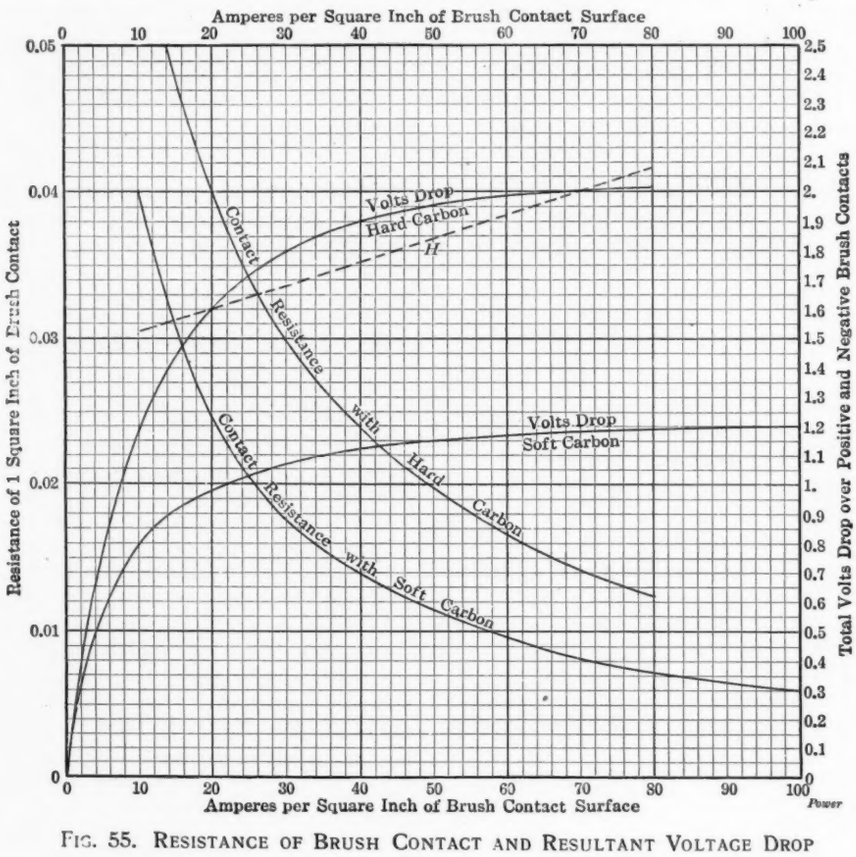

Amperes per Square Inch of Brush Contact Surface
Resistance of 1 Square Inch of Brush Contact
Total Volts Drop over Positive and Negative Brush Contacts
Volts Drop Hard Carbon
Contact Resistance with Hard Carbon
Volts Drop Soft Carbon
Contact Resistance with Soft Carbon
Power

FIG. 55. RESISTANCE OF BRUSH CONTACT AND RESULTANT VOLTAGE DROP

The quality of the carbon used in brushes varies widely from a very soft, graphitic carbon to a grade so hard that it feels gritty to the fingers. The softer the carbon, the lower its resistance and, consequently, the lower the resistance of the contact between the brush face and the commutator. The voltage drop at the brush face, therefore, is much less with soft-carbon brushes than with hard ones, and the loss in watts is, of course, correspondingly less. From this it would seem desirable to use brushes just as soft as can be obtained, but that is not true in most cases; where the voltage is very low and the current large, soft carbon is commonly used, but it is advisable to use brushes as hard as possible, within certain limits, for the same reasons (to be explained later) that carbon brushes are used at all, when copper brushes would give so much less loss.

Another peculiarity of the carbon brush is that the direction of current flow across the contact affects the relation between increase of current and decrease of contact resistance. When the current flows from the commutator into the brush, the contact resistance decreases much less rapidly, with increasing current, than when the current flows from the brush into the commutator. In some tests made in 1907 by Prof. E. Arnold, a distinguished German scientist, it was found that the drop at the positive brush of a dynamo decreased from 1 volt at a temperature of 104 degrees to 0.8 volt at 168 degrees while the drop at the negative brush decreased from 1 volt to 0.2 volt with the same temperature increase and current.

These various effects are very erratic, and it is impossible to give any rules or formulas that would enable anyone to estimate closely what resistance effects will be obtained with the many different grades of carbon. Besides, the mechanical conditions, such as roughness of the commutator surface, bouncing of the brushes, vibration of the holders in which the brushes are mounted, etc., all affect the effective contact resistance of the brushes.

Merely for the purpose of giving the student a general idea of the relation between the current density at the brush faces and the resistance of the contact with the commutator, the curves in Figs. 55 and 56 are presented. These give the average of a number of tests made with soft and hard carbon brushes of grades commonly used on dynamos and motors in this country. Fig. 55 looks a little complicated, but if the reader will follow the explanation carefully, the complications will straighten out without any effort.

The curve marked "Contact Resistance with Hard Carbon" gives the average relation between the current density at the brush faces and the resistance of the contact between the brushes and the com-

mutator, as obtained from the tests of a number of hard-carbon brushes. For example, with 20 amperes per square inch of brush-face contact, the resistance of one square inch of contact was 0.04 ohm (trace upward along the line marked 20 at the bottom of the diagram until you strike the curve, and then trace horizontally to the left-hand scale). At 40 amperes per square inch of brush contact, the resistance of the contact was only 0.024 ohm, and at 60 amperes per square inch it was 0.0165 of an ohm across one square inch of contact. From this it is evident that the more current there is going across between the brush and the commutator, the lower is the resistance of the contact. It would seem, therefore, that the proper way to work a dynamo or motor is to jam just as much current through the brush faces as possible, or, putting it the other way, to make the brush faces just as small as mechanical strength will allow. This is not true, however, because, while the contact resistance decreases with an increase in current, it does not decrease fast enough to prevent the increased current from increasing the watts lost at the contact, and this means increasing heat, which will ultimately cause trouble. If the brush faces get too hot, a soft brush will soften and deposit a sort of carbon paste on the commutator; a hard brush will also soften at a high temperature, but before that is reached it will crumble off in minute particles which scratch the commutator and lead to various other troubles. Even if no operating troubles were produced, the increase in watts lost at the brush contacts makes it unwise to carry the current density very high.

To return to the diagrams, the curves in Fig. 55 serve to illustrate the difference in the nature of the contact when soft and hard brushes are used and the results produced by changes in the current density at the brush faces. The curve marked "Contact Resistance with Soft Carbon" shows that at 40 amperes per square inch of brush-face area, the contact resistance for one square inch of face area was 0.014 ohm, at 50 amperes density it fell to 0.0115 ohm and at 64 amperes it was only 0.009 ohm.

It is the voltage drop and the watts lost, however, that are of practical interest. The curves marked for voltage drop with soft and hard carbon, in Fig. 55, illustrate the statement that the voltage drop remains almost constant within a certain range of current densities. For example, the total drop over both brushes (that is, the drop at the positive brush added to the drop at the negative brush), with soft carbon, is 1.12 at 40 amperes density, 1.15 at 50 amperes and 1.152 at 64 amperes per square inch. With hard carbon, the drop across both brushes is 1.6 volts at 20 amperes density, 1.8 volts at 30 amperes and 1.92 volts at 40 amperes per square inch.

The curve of Fig. 56 was plotted from the same tests that served for the curves just discussed. Taking the same densities as before, it will be found that the watts lost with soft brushes were 22 per square inch at a density of 40 amperes per square inch, 28½ watts at 50 amperes density and 37 watts at 64 amperes density. With hard carbons, the watts lost per square inch at 20 amperes density were 16; at 30 amperes density, the loss was 27 watts per square inch and at a density of 40 amperes per square inch, the loss went up to 38 watts per square inch. These figures demonstrate what was said as to the increase in losses with increased densities. Suppose, for example, that a machine was equipped with hard-carbon brushes having a total face area of 12 square inches and that the total armature current was 120 amperes. The positive brushes would have a total face area of 6 square inches and the negative brushes the same; therefore, the current density at the brush faces would be

$$\frac{120}{6} = 20$$

amperes per square inch of brush-contact area. The watts lost per square inch of contact area would be 16, and the total loss at all brushes would therefore be

$$16 \times 12 = 192$$

watts. Now suppose that one-third of the brushes were taken off, leaving a total brush-face area of 8 square inches; then the current density would be increased to

$$\frac{120}{4} = 30$$

amperes per square inch. The loss per square inch would be increased to 27 watts, and although the contact area had been reduced to 8 square inches, the total loss would be increased to

$$27 \times 8 = 216$$

watts, as compared with 192 before. Now suppose one-fourth of the remaining brushes were removed, reducing the total brush-face area to 6 inches. The current density would be increased to

$$\frac{120}{3} = 40$$

amperes per square inch and the loss would be increased to 38 watts per square inch, making a total loss of

$$38 \times 6 = 228 \text{ watts.}$$

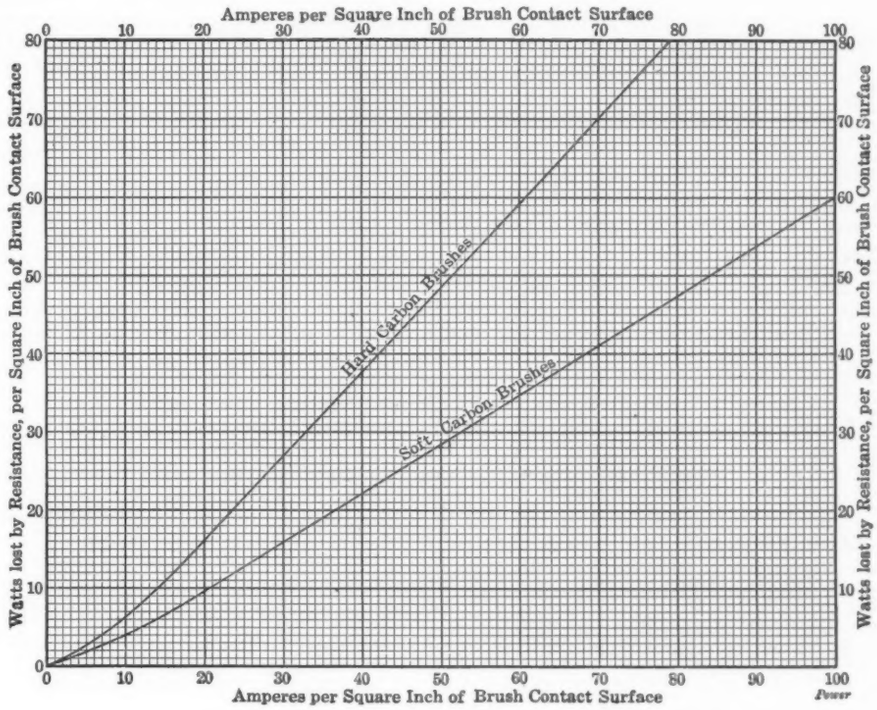

Amperes per Square Inch of Brush Contact Surface
Watts lost by Resistance, per Square Inch of Brush Contact Surface
Hard Carbon Brushes
Soft Carbon Brushes
0 10 20 30 40 50 60 70 80 90 100

FIG. 56. AVERAGE ELECTRICAL LOSS AT CARBON BRUSH FACES

It may not be quite clear to the student why the curves in Fig. 56 are plotted to show watts per square inch of brush-face area, while the voltage-drop curves in Fig. 55 give the total volts without regard to contact area. The reason is that the resistance of the contact decreases as the area increases, because the resistance of all electrical conductors follows that law. Thus at 30 amperes density, a brush having a face 1 inch square would have a contact resistance of about 0.03 ohm; the current would be 30 amperes (the contact area being exactly one square inch) and the drop would be 0.9 volt at the positive brush and the same at the negative brush (assuming for the moment equal contact resistances). The watts lost at each brush face would be

$$30 \times 0.9 = 27.$$

Now suppose that the brushes (one positive and one negative) had only ½ square inch face area each and the current were 15 amperes. The density would remain 30 amperes per square inch

$$(15 \times 0.5 = 30)$$

and the resistance of contact would be twice what it was before, because the area has been reduced one-half; the resistance at each contact, then, would be 0.06 ohm and the voltage drop would remain 0.9 as before, because

$$0.015 \times 0.06 = 0.9.$$

But to keep the current density at 30 amperes per square inch, the current was halved when the brush contact was halved; therefore, the watts lost at each brush face would be

$$15 \times 0.9 = 13.5,$$

or just half what they were before. The watts lost *per square inch* of brush face, however, would be the same. In the first case there were two brushes each having a square inch of face area, or a total of 2 square inches, and the watts lost were 27 at each brush, or 54 at both; this is

$$54 \div 2 = 27$$

watts per square inch of brush-face area. In the second case there were two brushes of ½ square inch face each, or a total of 1 square inch at both brushes; the watts lost per brush were 13.5, making 27 watts at both brushes, and the total area being 1 square inch, the watts per square inch were obviously 27.

In the explanation it has been assumed that the contact resistance of a positive brush is the same as that of a negative brush. That is not always true, but it does not affect the results because it is the total drop at both sets of brushes and the total watts lost at both sets that are considered, and these total results have been merely averaged between the two sets of brushes to simplify the computations. For example, it makes no difference whether at 30 amperes density the drop at the positive brush is 1 volt and that at the negative brush is 0.8 volt, or whether the positive brush drop is 1.5 volts and the negative brush drop 0.3 volt, so long as we know that the total drop over both brushes is 1.8 volts.

The student is again reminded that while the resistances, drops and losses indicated by the curves in Figs. 55 and 56 may come close to those obtained in practice with average hard and soft carbon brushes, they are not supposed to give hard and fast values—only to illustrate the general performance of carbon brushes. It is possible to get very different figures from the same brushes on two different machines or even on the same machine under different running conditions.

Turbo-generators of 18,000 Horsepower for the Victoria Falls & Transvaal Power Company

The Allgemeine Electricitäts-Gesellschaft recently installed five 18,000-horsepower turbine-generator units at the Rosherville Dam power house of the Victoria Falls & Transvaal Power Company, in South Africa. The specified continuous output of each unit is 12,000 kilovolt-amperes, or 9600 kilowatts with a lagging load of 80 per cent. power factor. The windings of the stator are connected in star or Y fashion, and the potential between terminals is 5000 volts. The frequency is 50 cycles and the speed 1000 revolutions per minute. The stator is equipped with bar-fork windings. The exciters are direct connected and deliver current at 220 volts.

Each generator delivers to a step-up transformer of equal full-load rating, capable of raising the voltage to 20,000 or 40,000.

The guaranteed steam consumption is 5.8 kilograms (12.8 pounds) per kilowatt-hour with a power factor of 80 per cent., steam at 205 pounds per square inch, superheated to 330 degrees Centigrade (626 Fahrenheit), and cooling water at 15 degrees Centigrade (59 Fahrenheit) for condensing.

LETTERS

Effects of a Bad Joint in the "Field" Lead of a Compound-wound Dynamo

The engineer of a small plant sent in a hurried call for a man to locate the trouble with one of his generators and I was sent out on the job. The plant consisted of three 50-kilowatt 125-volt compound-wound dynamos direct connected to gas engines running on producer gas.

The engineer informed me that one of the dynamos refused to carry its share of the load when running with either of the other two. Moving the field rheostat of the faulty machine had little effect except to raise the busbar voltage. The field windings were tested for grounds and short-circuits and found to be all right. The german-silver shunt was carefully examined, the brushes were in the correct position and everything seemed right except for a dark blue discoloration on the commutator. The engineer said this always appeared after a machine had been shut down for several hours, and was caused by the producer gas from a leaky pipe attacking the copper.

After some thinking it became apparent that if the positive lead should be open somewhere between the generator and the busbar the trouble would be accounted for, since any current flowing through the armature of the lagging machine would have to pass through the series field winding of the machine with which it was working in order to reach the positive busbar, thereby strengthening the field of the other machine instead of its own.

Acting on this theory, the three-blade switch of the faulty machine (No. 2 in the sketch) was closed, the circuit-breaker being open and the machine standing still. In this case No. 1 was already on the line and closing the main switch of No. 2 put the series winding of No. 2 in parallel with that of No. 1. This should have diverted half the current from the No. 1 series field winding and reduced the voltage. But there was no

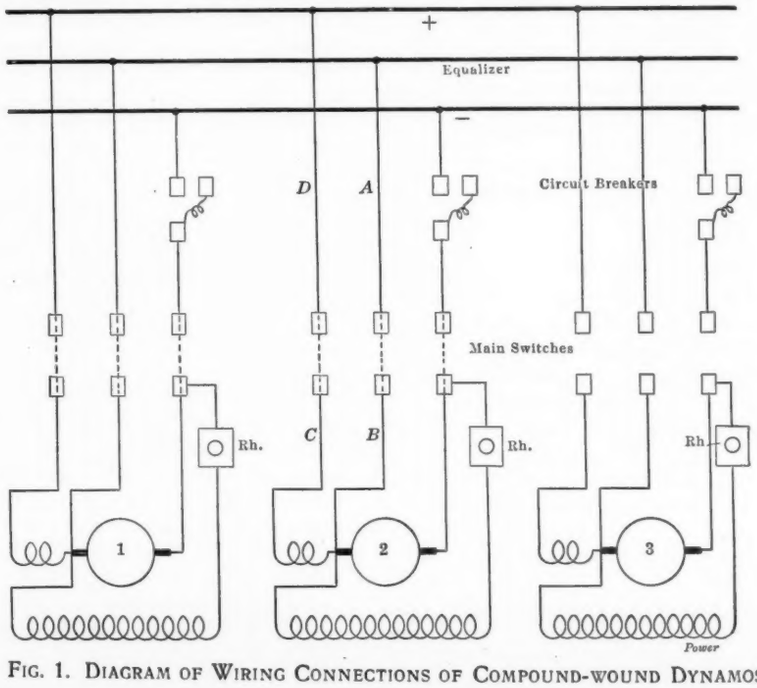


FIG. 1. DIAGRAM OF WIRING CONNECTIONS OF COMPOUND-WOUND DYNAMOS

effect on the voltage, thus indicating that no current flowed from the equalizer busbar to the positive busbar through the circuit *A, B, C, D*. With the aid of a lamp line it was found that no current would pass through the joint between the positive adapter stud and the busbar, and when the stud was unscrewed it was found to be corroded. The joint had never been actually tight and the action of the gas from the leaky pipe had gradually reduced the contact surface until it formed an open circuit. After this joint was cleaned the trouble disappeared.

Had this happened to the equalizer connection instead of the positive busbar connection, the first symptom of trouble would have been fireworks on attempting to parallel the machines. After this was made clear the engineer took steps to correct the leak in the gas pipe.

A. BODDIE.

Boston, Mass.

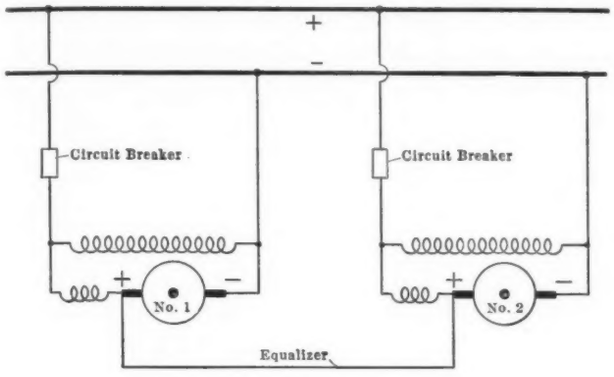


FIG. 1. MR. POLLARD'S GENERATOR CONNECTIONS

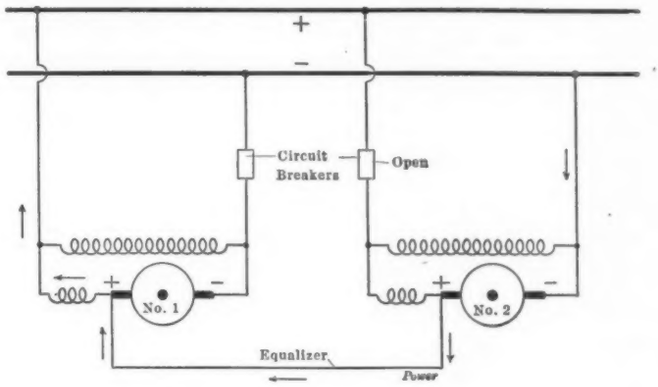


FIG. 2.

Speaking of smoking shunts reminds me of an experience somewhat similar to that of Mr. Roberts, described in the May 31 issue. We had two 500-volt street-railway generators running in parallel and connected as shown by the accompanying diagram. There was no trouble as long as the load was light, but just as soon as the heavy load came on, the shunt strip of No. 1 machine would smoke. It was several days before we could locate the trouble as it did not appear every day. It was discovered by the blade and jaw *P* of the No. 2 main switch getting hot and changing color when the load came on; the minute the load went off the blade was cool.

The trouble was poor contact between the blade and the jaw. It was found that the blade had some high spots ("blisters") which would not allow the faces of the blade to lie flat against the jaw and utilize its full contact surface. The current from No. 2 armature, instead of passing principally through the jaw *P*, was shunted through the equalizer to the series winding and shunt strip of the No. 1 machine. Of course, No. 1 machine would take most of the load when the heavy load was on, and the shunt would only smoke at those times.

LOUIS J. GORILLA.

Ironwood, Mich.

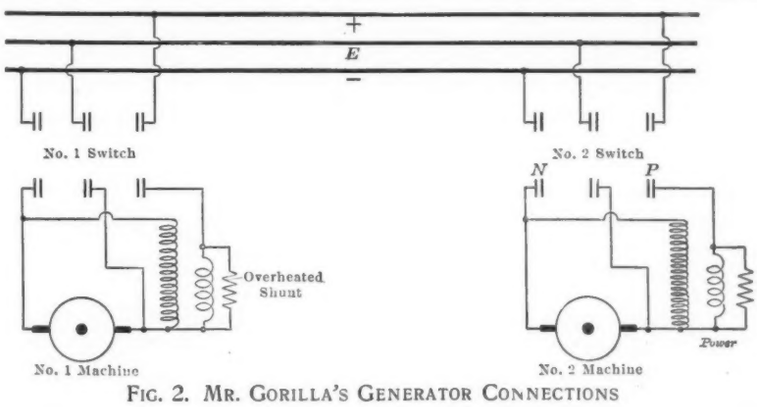


FIG. 2. MR. GORILLA'S GENERATOR CONNECTIONS

Circuit Breaker Connections for Generators in Parallel

Two 200-kilowatt 550-volt generators were first connected up for parallel operation as shown in Fig. 1, with the circuit-breakers of both machines connected in the leads from the series field windings. There was a mechanically operated field rheostat on No. 1 generator rigged so that when the circuit-breaker blew out, it would cut in the resistance to prevent the machine from flashing over, as described in the issue of June 7. After the machines were run awhile the circuit-breaker on No. 1 blew out and the automatic rheostat cut in the field resistance. Current still flowed from the No. 2 machine through the series field winding, however, and kept the voltage up and caused trouble at the brushes so that something else had to be done. The circuit-breaker on No. 1 was changed to the other lead, and there was more trouble. When there was a short-circuit, both circuit-breakers blew out, but the line was still getting current. On tracing it out, it was found that No. 2 machine was connected to the busbars by its own negative lead and by the equalizer and the series winding and positive lead of No. 1 machine, as shown in Fig. 2. Then the circuit-breaker on No. 2 machine was changed to the negative lead, and there has been no more trouble.

LEON L. POLLARD.

Fairfield, Me.

[One of the fundamental and long-recognized rules for connecting two or more compound-wound generators to the same busbars is to put ammeters and single-pole circuit-breakers in the direct leads—that is, the leads which do not come from the series windings. An ammeter in the "compound" lead frequently does not indicate the true current of the machine, and a single-pole circuit-breaker in that lead is useless, as Mr. Pollard has found out.—EDITOR.]

A large Humphrey pump is being designed for construction in Germany, which will deliver over a ton of water per second, with a lift of 200 feet, giving 7000 horsepower in the water lifted. A very high fuel economy is expected, and the pump is to be used to demonstrate the utility and economy of the gas-hydroelectric system advocated by Mr. Humphrey for central electric stations. The Humphrey pump, it will be remembered, is an internal-combustion apparatus, the gas being exploded against the moving column of water itself, and the oscillations of that column being used to effect the intake, compression, etc.

Gas Power Department

Gas Engines for Driving Alternating Current Generators*

By H. G. Reist

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

The problem of driving an alternating-current generator by means of a gas engine is not inherently different from that of driving it by a steam engine. If the shaft of the engine turned with a uniform motion, no difficulty would be experienced and no special design would be necessary. It is the variation in angular velocity and speed that affects the driving of alternators.

If the current of a single generator is used for lights or for heating, as in electric furnaces or in electrolytic work, variations in velocity either during a single turn or due to the hunting of the governor will simply increase and decrease the load as the speed varies. If induction motors are driven from a single generator, it is only under peculiar circumstances that any trouble is experienced due to speed variations in the engine, because this type of motor does not have to follow exactly; it is as if it were belted to the engine, the connection being slightly flexible.

A synchronous motor or rotary converter, on the other hand, must keep in phase and behave as though geared to the engine, and must respond to all its speed variations. If it does not keep absolutely even; that is, if its phase relations change, cross currents will flow. When two or more generators are operated in parallel, their behavior is similar, any angular departure of one from the other causing a cross current. The volume of the cross current depends, with any given design of generator, on the angular departure of the generators from each other. This departure may be twice the angular variation of the engine-rotating parts from a mean position, because one may be a maximum distance ahead while the other is in the most backward position.

If the generators were mounted on the shaft so that the relations of the poles to the cranks were identical, and if it were possible so to synchronize them that the corresponding cranks of engines to be run together were exactly together, no cross currents would flow, because the engines would slow down and speed up together. This is not feasible, however, and it becomes necessary to design the engine to run with a fairly uniform rotation. It has been found good practice to limit the variation from a mean position of the revolving parts of the electric generator to 1¼ electrical degrees.

An electrical degree is 1/360 part of the distance from the center of one field magnet pole to the center of the next pole of the same polarity; therefore, on a two-pole generator an electrical degree is one mechanical degree of the polar circle of the machine; if the generator has four poles, an electrical degree will be one-half a mechanical degree of the circle to which the pole faces are bored; if there are six poles, it will be one-third of a mechanical degree. In general, to reduce electrical degrees to mechanical degrees, we must divide the allowable variation by one-half the total number of poles on the generator; so that for a twenty-pole machine the 1¼ electrical degrees mentioned above would be 0.125 actual degree on the circumference of the flywheel. From this it is evident that with a generator of many poles, a more even speed is needed than for one with few poles. For a 60-cycle generator, which at a given engine speed has 60/25 as many poles as a 25-cycle generator, the evenness of running must be 2.4 times that for a 25-cycle generator, at the same speed.

The cross currents between two electrical generators tend to speed up the lagging machine, bringing them more closely into synchronism. If there were no inertia the rotating parts of the generator and flywheel would quickly get into synchronism, almost eliminating the cross currents, but this is impossible. The cross currents are a factor of the amount of inertia with a given natural angular variation, and it will readily be seen that from this standpoint the larger the flywheel the less effect a given value of current or torque will have on the mass. If the flywheel is very large, the current which it may be practical to allow to flow between the machines may not be able to draw them together at all. Hence a large flywheel, while useful in obtaining uniform rotation so far as the engine is concerned, prevents the current flowing between the machines from being very effective in drawing them into synchronism. This shows that it is desirable to obtain uniform rotation in other ways than by the use of an excessively heavy flywheel. Currents flowing between machines occasion losses in the copper and this adds to the heating of the machines. They thus reduce the output with a given rise of temperature and reduce the efficiency.

Certain elements of design may be introduced into an electrical generator to make it less sensitive to slight variations in turning moment supplied by the engine, such as building a generator of poor regulation. The regulation must not be too poor, however; otherwise the operation of the system will be unsatisfactory. A "squirrel-cage" winding in the poles of the generator allows secondary currents to flow in this part of the structure and increase the torque, tending to draw the generators together with a given interchange of current between the two machines. This is of great assistance in parallel operation of generators and should generally be applied on generators to be driven by gas engines. If a flexible connection could be provided between engine and generator it would greatly assist in satisfactory parallel operation, but this connection is generally applicable only on small machines. The ultimate solution lies in the direction of greater uniformity of motion in the engine itself.

Uniformity of rotation of gas engines is dependent on a number of elements of design, such as the number of impulses per revolution, which in turn is dependent on the number of cylinders and arrangement of cranks and on whether a two- or a four-stroke engine is used; the compression and weight of the reciprocating parts; the time of ignition; the weight of the flywheel. The use of a heavy flywheel, however, while one of the simplest expedients, is the least desirable method of obtaining even rotation of the engine shaft, and other means should be used to obtain as uniform rotation as possible.

The following seem to be the desirable characteristics of gas engines for driving alternators:

(*a*) High speed. This will require fewer poles with a given frequency and a greater angular variation will be allowable.

(*b*) A light flywheel. This will allow the current to keep the generators together with a minimum disturbance.

(*c*) Large engines should be built with many cylinders and cranks so placed as to contribute to an even turning moment.

*A paper read at the Atlantic City meeting of the American Society of Mechanical Engineers.

Jacket Water Temperatures

By John S. Leese

The writer recently made a series of tests on a single-cylinder Simms gasolene engine, in which the load was varied and the revolutions were kept constant. The effect of the temperature of the cooling water at outlet, although not the original motive for the tests, is interesting. The inlet cooling-water temperature was kept constant at 42 degrees Fahrenheit. The results are given in the table herewith.

RESULTS OF TESTS.

Test No.	Duration, Minutes	Revolutions per Minute.	Brake Horsepower.	Temperature of Cooling Water at Outlet in ° F.	Thermal Efficiency on B.H.P., Per Cent.
1	30	1000	1.875	81	15.12
2	25	1004	2.25	88	15.17
3	25	1002	3.45	94	16.12
4	30	1000	3.68	100	16.66
5	25	998	4.49	105	17.29

In each case, before readings were commenced for a test, the engine was run long enough to allow the conditions to become constant.

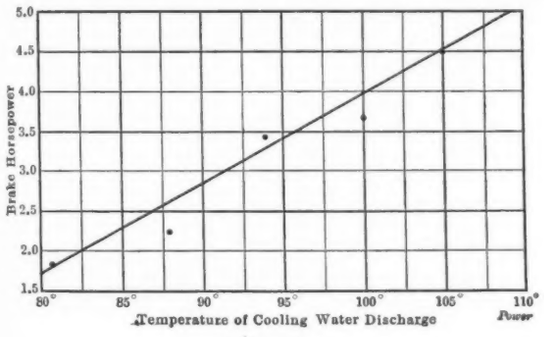


FIG. 1

Fig. 1 shows the relation between load and jacket-water outlet temperature, and Fig. 2 the thermal efficiency and outlet temperature relation. These results confirm the tests made two or three years back by S. F. Edge on a Napier gasolene engine, in which, however, the load and revolutions were kept constant and the cooling water alone was varied. Those tests showed that the most efficient temperature for the jacket water from the point of view of brake horsepower and fuel consumption to be 212 degrees Fahrenheit. I do not wish to be understood to mean that the water should be carried at this temperature in practice; my object is merely to point out that an appreciable loss is entailed by having the water running cold at the outlet, as one finds it in some plants. If the outlet water be allowed as hot as one can bear it on his hand, excellent results are obtained in practice.

Gas Engine Troubles

By James W. Little

Much has been said and written at different times about the erratic behavior of gas and gasolene engines. It has been my experience that a great deal of the trouble is due more to the lack of a thorough understanding of the principles of operation than to any mechanical imperfections in the engines. I dare say, without fear of contradiction from those who have made a study of, and have had experience with, the internal-combustion engine, that the majority of cases of trouble have been remembered with a sense of the ridiculous. Generally speaking, it is something so simple that it is overlooked in the strenuous search for the trouble. Usually the operator "goes after" the engine with a monkey wrench and pulls it apart only to find nothing apparently wrong.

After such a wholesale dismembering it is often the case that the engine, on being put together again, starts up promptly, to the mystification of the operator.

Then again, this operation may be gone over and still the engine refuses to start, and someone else has to be called in to diagnose the case.

It has been said, and with a great deal of truth, too, that nine-tenths of the failures to start, and similar troubles, are due to faulty or completely disabled ignition. In view of this probability, it is rather unwise to take an engine to pieces before investigating the ignition system thoroughly. The learning of a few simple principles would be a better use of time expended.

There are several things that may impair or totally disable the ignition system. Starting with the battery cells, if a battery is used, it is well to see that they are connected according to the directions usually sent with the engine. It is a good plan to scrape the connectors clean, and also the nuts of the binding posts where the connectors lead from cell to cell, then screw these nuts down finger tight and keep them so. Following the wires out to the spark coil and switch, the same suggestion as to cleanliness and tight connections applies. The wires leading to the binding posts on the igniter may be scraped clean, and with the switch closed the spark may be tested by touching the bright ends together and then quickly separating them, whereupon, if everything is as it should be, a good, bluish-white spark will result. If a lot of little sparks are the result, imperfect ignition may be expected, because this usually indicates a short-circuited spark coil.

The igniter insulation may be tested by connecting to the insulated electrode one of the wires and touching some bright part of the engine with the other, taking care that the electrodes of the igniter are well separated. If no spark results, the insulation is all right. It should be seen that the movable electrode is not corroded and gummed so it is with difficulty moved; it should move freely.

The valves of the engine should be tight when closed, as a leaky valve may so spoil the compression that the ignition is unreliable.

One of the reasons why an engine that has stopped, been taken to pieces and put together again will sometimes start, is that an exhausted ignition battery has had time to build up again. When this is the case, however, the battery soon becomes exhausted again and ignition ceases, stopping the engine. [Another reason for this experience, if the engine runs on gasolene, may be that too much gasolene was delivered to the cylinder during the efforts to start, and this has time to evaporate while the engine is being taken down.—Ed.]

Sometimes an engine positively refuses to start some morning, although it ran right up to shutting-down time the night before. Smutty igniter points are often responsible for this. Another common cause of this behavior is leaving the ignition circuit closed when shutting down. When this is done the engine is liable to stop with the timer in contact and run down the battery over night.

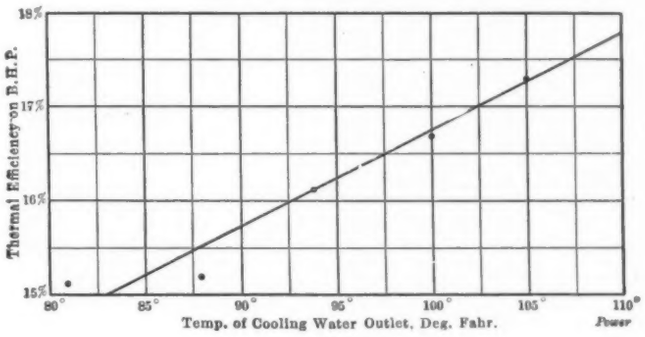


FIG. 2

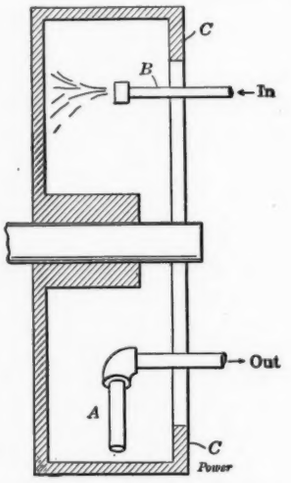
A more recent invasion of the leather-belting field is now reported in the application of paper belting made in England, the claim for it being that it is stronger than leather, will not stretch, and is less subject to climatic changes.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Pulley for Use with Prony Brake

The sketch shows a pulley for use with a prony brake. The outer circumference is turned flat and flanges are left projecting inward as at *C*. A ¼-inch pipe *B* with a cap having a very small hole drilled in its center, is connected to a source of water supply and the interior of the pulley is thus kept supplied with cool water. At *A* is a ½-inch pipe supported so that its end is about ⅜ inch away from the interior circumference of the pulley and pointing as shown in the sketch. This acts as a scoop and prevents the flanged part from becoming filled and overflowing. Such an arrangement prevents the pulley from overheating and keeps the water supply constant.



CROSS-SECTION OF PULLEY

A. H. ANDERSON.

Chicago, Ill.

Water Wrecks Engine

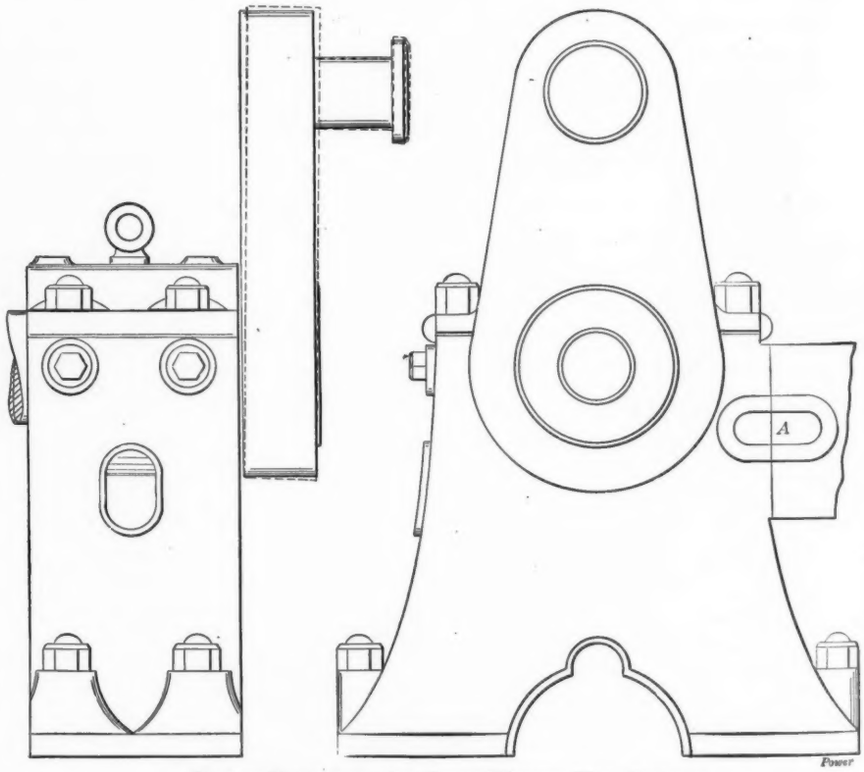
That an engine will act as a pump under certain conditions was demonstrated by an accident which came within the writer's observation a few years ago. The engine was a single 24x48-inch Corliss and could be run either condensing or noncondensing. It was belted to a short jackshaft, that was coupled with the main shafting by a jaw coupling.

On shutting down, a regular routine had been followed which had always been successful until a new man came on watch, and then the inevitable happened. It had been the usual custom to cut out the dynamos, open the jaw coupling on the jackshaft, close the engine throttle and after the engine had been stopped, to shut down the independent air pump and the condensing plant; the exhaust cut-out valve, between the engine and the condenser being left open, as this engine was usually the first one started again on Sunday night.

However, the new man became confused and shut down the air pump first; closed, as he supposed, the injection valve, and then opened the jackshaft clutch, closed the throttle and hooked up the governor. The condenser was on top of the water end of the independent air pump, and had never been fitted with an injection valve, but in lieu of this, the injection water had been regulated always by the valve in the condenser, whose only office was to adjust the amount of the opening to the load, and when this valve was apparently closed it was kept ¼ inch off its seat by four small lugs; these being intended to act as a guard against closing the valve completely, when adjusting it for light loads, or cold injection water.

After the throttle had been closed and the engine slowed down, it being kept moving by the momentum of the flywheel, the vapor was destroyed in the steam cylinder and the piston being absolutely tight, the engine acted as a pump. It was still turning very slowly, the wristplate not having been unhooked, when the water was lifted and the crash came, just after the automatic valve on the condenser had opened and destroyed the vacuum.

Referring to the sketch, the link *A*, as well as the bolts between the main bearing and the bedplate, let go. This allowed the pedestal to shove away from the bedplate and brought the flywheel up against the side of the pit. The crank was shoved out of line 3/16 inch, as shown by dotted lines, and the connecting rod was also badly sprung at the crank end.



CRANK DISLODGED AND LINK WHICH WAS BROKEN

There now began some hasty makeshift repairs, until a new crank could be obtained. First, a new link was made to replace the one at *A* and the bedplate and pedestal were brought back to position; a new set of bolts were made and fitted and the connecting rod was

heated and sprung back into alinement. While this was going on it was decided that the only thing that could be done with the crank was to file the pin parallel to the shaft. The shaft being tried for level, it was found to be in perfect alinement, so far as the level was concerned.

The crank was first placed upon the top quarter and a dead level filed across the pin; then a similar level was filed with the crank upon the bottom quarter, care being taken to remove as little metal as possible; next, the same amount of metal was removed from the pin with the crank upon both centers. These four spots were increased to eight, then sixteen, and finally thirty-two. Then the corners were carefully filed off to make the pin round.

An old set of crank-pin brasses was now poured with lead, fitted to the pin, and 3/16 inch planed off one side, and a "dutchman" fitted on the other side, to bring them in line with the connecting rod and the distorted position of the crank. When the pin had been filed as close as possible, the brasses and rod were connected up, and the engine started, and lard oil and flour of emery were fed to the pin, the engine being run light at about 50 revolutions per minute. After a run of two hours the engine was stopped and the brasses were opened up for an inspection of the pin. As the filing had been an excellent job, there were but few hard spots to take off, and while this was being done, the brasses were rebabbitted after melting out the lead, and fitted to the pin. While the crank-pin brasses were being fitted, the brass plate was removed from the crank center, and a hole chipped into the crank on the two opposite sides of the shaft, in order to allow accurate calipering of the shaft to make a gage which was sent to the shop to bore the new crank to.

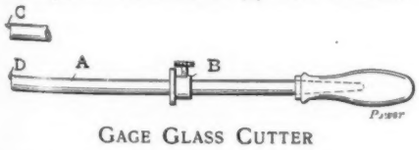
In the mean time the engine was started up and ran under full load for three weeks while awaiting the new crank, and gave no trouble whatever.

E. A. BLACKWELL.

Kingston, N. Y.

A Gage Glass Cutter

The following sketch shows a gage-glass cutter which has been found to perform its work satisfactorily and to cut as well as any wheel cutter. The stem *A* is made of steel about ¼ inch in diam-



GAGE GLASS CUTTER

eter and 8 or 10 inches in length. The cutting point is formed by first filing down the end of the stem to form the projection as shown at *C*. This is then heated to a cherry red and bent up as at *D*, after which it is again heated and then hardened by quenching in cold water. This being done, it is dressed to a sharp edge with an oil stone. The slide *B* and the handle are then put on.

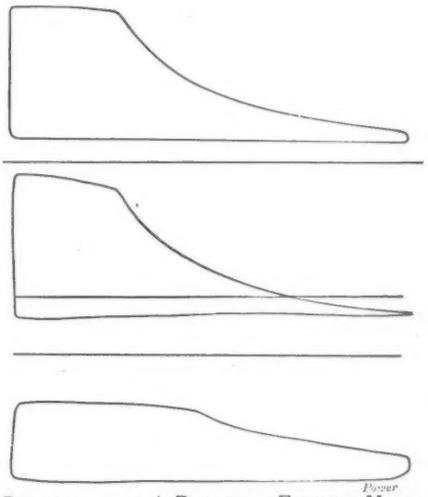
R. L. MOSSMAN.

Tampa, Fla.

Pumping Engine Record

The figure shows diagrams taken from a 36, 60 and 90 by 66-inch triple-expansion pumping engine which were taken during the acceptance test. The steam pressure was 180 pounds, the vacuum, 27.7 inches and the total water pressure was 96 pounds. The average number of revolutions per hour was 1208.

The duty per 1000 pounds of dry



DIAGRAMS FROM PUMPING ENGINE HOLDING WORLD'S RECORD

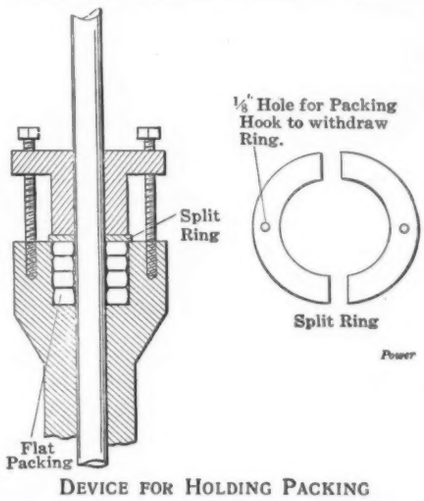
steam was 184,476,200 foot-pounds. This is a world's record for a pumping engine.

H. R. BLESSING.

Philadelphia, Penn.

Means of Keeping Packing in Place

We formerly experienced much trouble in keeping the packing around the plunger of our hydraulic accumulator, which is not of modern design and has the stuffing-box gland made with a decided taper. The depth of the stuffing box is only 2½ inches and a pressure of 2000 pounds per square inch is carried on the piston.



DEVICE FOR HOLDING PACKING

To remedy the trouble, I had a small steel ring (see sketch) made in halves and placed on top of the packing as a follower. The ring is made of a size to allow 1/16-inch clearance around the plunger to avoid any danger of cutting, and a ⅛-inch hole is drilled in each half to allow the ring to be withdrawn with a packing hook when necessary.

Before using the ring, it was necessary to repack the gland every three or four days, but now a packing will last for about three weeks.

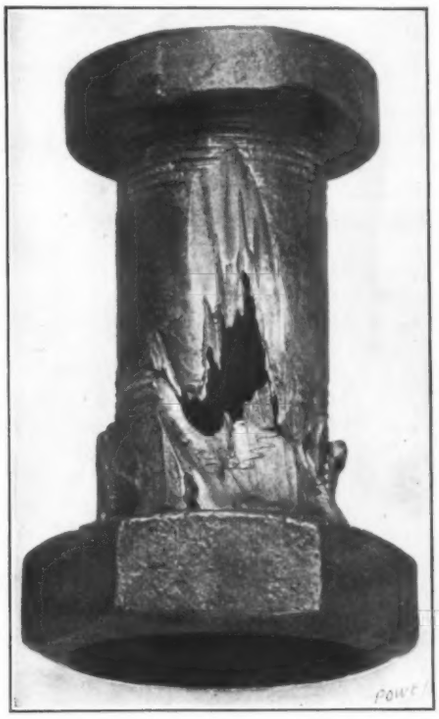
C. C. HARRIS.

Springfield, Mass.

A Case of Rapid Erosion

The writer's attention was recently called to the very rapid erosion which took place in a gasket union shown in the accompanying photograph.

This union was taken out three weeks after it had been installed. It connected



UNION SHOWING EFFECTS OF EROSION

a steam trap to a 6-inch water leg, 440 feet from the boiler, and carried steam which was delivered to the engine at 130 pounds pressure. The trap and joint were located in a brick and cement pit and were covered with water in which there was considerable sand and grit.

A probable explanation of this erosion is that the escaping steam stirred up sand and grit, which was sucked into the current of escaping steam and the combination worked like a sand blast. The writer would like to know if any of the readers of POWER ever had a similar ex-

perience, or if anyone can offer an explanation other than the above.

E. M. HALL.

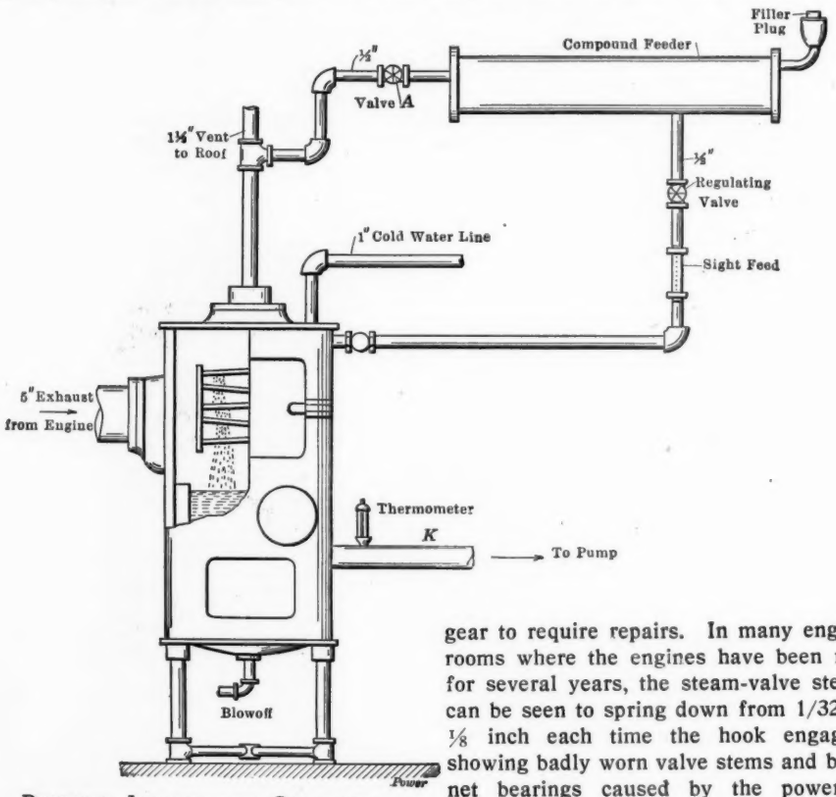
Lexington, Mass.

Boiler Compound Feeder

The accompanying sketch shows a type of boiler-compound feeder which I am thinking of installing, but should first like a few opinions regarding it from POWER readers.

The feeder is made of a piece of 4-inch pipe 2½ feet long, capped at both ends and tapped for ½-inch pipe. The filler plug consists of a 1¼x½-inch reducer. At *A* the feeder is connected to a 1½-inch vent pipe leading to the roof.

I figure that with the valve *A* open, a little pressure will be created which with



PROPOSED LOCATION OF COMPOUND FEEDER

the weight of compound in the feeder will more than balance any tendency to back up through the regulating valve. Also, steam entering from *A* will circulate the compound and act as a vent. Backing up should be considered, for when the engine carries a heavy load there is enough back pressure in the heater to cause the cold-water regulating-valve float to kick up quite a rumpus. The sight feed, which is made from fittings from an old lubricator, is adjustable and independent of valve *G*, and will take the place of a gage glass on the compound feeder, thus saving the unnecessary opening of the feeder or heater to make sure it is feeding all right.

The compound and cold-water feeding together and attaining the temperature of 210 degrees Fahrenheit, ought to cause some scale precipitation in the heater which is the point aimed at. The feeder could be put on the pump-suction line as at *K* with much less trouble, but whatever precipitation that takes place in the heater would then take place in the feed line. This is to be avoided as far as possible as it is much easier to clean the heater than the feed line.

CHARLES T. REED.

Elizabeth, N. J.

Operation of Dashpots

One has but to observe the valve gear of an engine and to converse with experienced engineers, to become convinced that the steam-valve stems and their bearings are the first parts of the valve gear to require repairs. In many engine rooms where the engines have been run for several years, the steam-valve stems can be seen to spring down from 1/32 to ⅛ inch each time the hook engages, showing badly worn valve stems and bonnet bearings caused by the powerful downward pull of the dashpot.

Some builders have recognized this fact and have placed the drop levers inside of the bonnet thus lessening the strain, but this plan has its drawbacks and if the dashpot were always operated carefully and properly the change would not be necessary. In almost every instance of badly worn steam parts the dashpots will be noted to be acting with too much force.

Repeated experiments, using an indicator, with the dashpot seating rapidly or slowly will prove to the satisfaction of any engineer that a rounding cutoff will remain rounding and a square corner will still be square in either case. This being true there is clearly an advantage in favor of the slow movement.

The weight due to the atmospheric pressure on a 4-inch plunger would approximate 188 pounds provided a perfect vacuum were attainable in the vacuum chambers. Making due allowance for some air entering, there must still be quite a weight, the lifting of which from 80 to 100 times a minute represents considerable power expended. But that is not the point. The more important fact is the strain upon the pins, the downward wear of the valve stem and bearing, the rapid wear of the hook-plate edges, and the friction and wear on the knockoff cams and friction plates. Also, there is added friction and strain on the wristplate and governor connections and a tendency to noise, shock and rattling throughout the entire valve gear.

The writer's method of operating dashpots is not new but it has been suggested to many appreciative engineers who had the impression that because certain attachments for the control of dashpots were furnished with the engine, they should never be changed or disturbed. The correct way is to get the best possible fit to the cup leather or packing ring and then provide means for killing the surplus vacuum by admitting air into the vacuum chambers, using the least possible vacuum necessary to do the work. At all times the vacuum should be strong enough so that the plunger will strike bottom when the exhaust valve is opened on the air-cushion chamber. This can be accomplished by the use of an in-and-out-check valve attached to the dashpot. By this means the pot is always under control of the operator who by the simple operation of the air cock and cushion valve can vary the seating speed at will.

F. C. HOLLY.

Yazoo City, Miss.

Condensed versus Fresh Water for Making Steam

I have been a subscriber to engineering magazines for almost forty years and have never seen an explanation given of why fresh water will make more steam than condensation, or returns from a heating system.

A great many of the old-time engineers know it to be a fact but have never given it the necessary consideration.

We all know that fresh water does not make clear ice; it is full of air globules and must be boiled to extract the air before it will make clear, solid ice. For the same reason a hot-water pipe in a bath room or kitchen will burst with a slight frost much sooner than the cold- or fresh-water pipe. This is because whatever elasticity there may have been in the water has been removed by boiling the air out of it. Nearly the same results are obtained by heating the feed water in an open heater. If fresh, cold water is pumped into a closed heater, and heated to 212 degrees, all the air globules expand to a great many times their bulk

and become part of the steam immediately upon entering the boiler. This air must be heated to the temperature of the steam at the expense of fuel. I have no means of making a test but I fully believe that it is more economical to run the condensation into the sewer and use fresh water through a closed heater if there is enough waste heat to bring the temperature to 212 degrees without using live steam. Besides, the exhaust steam is impregnated with cylinder oil and it is almost impossible to keep it out of the boiler.

CHARLES STEVENSON.

St. Louis, Mo.

How Should Boilers Be Set?

I would like to hear what the readers of POWER have to say regarding the proper hight a 72-inch by 18-foot boiler with seventy 4-inch tubes should be set above the grates. It is our intention to set the boiler 42 inches above the grates. The bridgewall is to be 30 inches high and hollow, communicating with the outside through the register door and with the furnace—8 inches below the top of wall—by every other brick being left out. The boiler-feed pump exhausts into the ashpit.

Would anyone recommend "An Economical Boiler Furnace" illustrated and described in POWER, June 23, 1908?

HENRY SHOUT.

Paris, Ky.

An Example of Self-Education

I have some bright young men working for me, and the other day I walked into one of our engine rooms and asked one of our assistants if he could figure a problem, and gave him the following:

Two mills each burn 100 tons of coal per day; in one the stack temperature of the waste gases is 450 degrees, in the other 200 degrees. Find the saving in tons of coal per day in the second plant over that of the first.

He submitted the following solutions which pleased me very much:

Eighteen pounds of air are required per pound of coal for best combustion.

$$200{,}000 \times 18 = 3{,}600{,}000$$

pounds of air required for 100 tons of coal.

Heat required to raise one pound of air one degree Fahrenheit is 0.23751 B.t.u.

Therefore

$$3{,}600{,}000 \times 0.23751 \times 250 = 213{,}759{,}000$$

B.t.u. going up the stack in plant No. 1 in excess of that in No. 2.

The B.t.u. in each pound of coal = 14,500.

Hence,

$$213{,}759{,}000 \div 14{,}500 = 14{,}742$$

pounds of coal required to heat this air from 200 to 450 degrees.

And,

$$14{,}742 \div 2000 = 7.371$$

tons of coal per day wasted.

This young man after one year in the high school, on account of the death of his father, came to work for me. He has always been a student, and there is hardly a day that I do not catch him with a book and pencil in his hand figuring out some problem. For the last two years he has taught in one of our city evening schools, instructing firemen and engineers, as well as attending to his duties at the mill during the day. This goes to show what a person can accomplish by trying, and I predict a great future for this young man.

GEORGE H. DIMAN.

Lawrence, Mass.

A Substitute for Oil Packing

Not having any specially prepared oil packing at hand, I was compelled to pack the piston rod of an oil pump with ordinary steam piston-rod packing. While this kept most of the oil in the cylinder, a considerable quantity leaked out along the rod and soaked through the packing. After emptying the drip pans beneath the pump several times, and doing much extra wiping and cleaning, on account of the superfluous oil in the vicinity of the pump, a barrel of soft soap caught my eye, and I decided to use some of its contents in an attempt to overcome the difficulty.

I removed the packing, put a little soap in the bottom of the gland and rubbed a liberal quantity of soap into each ring of packing. I then replaced the packing and the pump has since been running steadily, without the loss of a particle of oil through the gland.

ROBERT ROE.

Hamilton, Ohio.

Explosion of Pipe Line

The line was of 1-inch extra-heavy pipe connecting to two three-stage air compressors supplying two Diesel engines of 450 horsepower each. Being a temporary installation, it was made up of numerous short lengths connected by couplings, unions and tees. These fittings were of the tight-joint type and of steel and were supposed to withstand 2000 pounds per square inch.

The writer had thrown the load off one unit at the switchboard and had signaled for the assistant to shut it down when, with a deafening report, six of the fittings burst and flew in all directions. Four tees and two ells let go, while two tees connecting the branch lines between the others held all right. There were two different weights of metal used in the fittings and five of the lighter grade burst while only one of the heavier grade let go.

The cause may have been due to several things: The line was poorly supported and in carrying air at 1100 pounds pressure it became very hot. The fittings were uneven in thickness and had probably crystallized under the continued heating and cooling. It is possible that there was enough oil in the line to ignite and cause an excessive pressure, although the gage showed 1150 pounds at the time of the explosion. There are relief valves, set at 1200 pounds, on each compressor, but there were none on the line so the supposition is that the flow of air having nearly stopped, the temperature rose rapidly and igniting the oil was sufficient to burst the fittings.

G. H. KIMBALL.

Southbridge, Mass.

Pipe Covering Materials

In discussing pipe-covering materials mention is seldom made of mineral wool. It is said to be short lived. A couple of years ago we covered a number of pipes with mineral wool, and were told to wait three months and see where our mineral wool would be. We have waited but it is still there. Furthermore, in a plant not far from here mineral wool which was put on ten years ago is said to be as good as ever.

In tests conducted by Professor Ordway, a covering made of carbonate of magnesia and a small percentage of asbestos transmitted 2.5 B.t.u. per square foot per minute. In tests conducted by George M. Brill, mineral wool was found to transmit 1.29 B.t.u. per square foot per minute, or about half as much as magnesia.

In the March 29 issue of POWER, J. H. Boughton cites an instance of the saving effected by the use of what was probably 85 per cent. magnesia. He states that the condensation was reduced from 74.4 to 11.58 pounds per hour; that is, 67.87 pounds of steam were saved. If mineral wool had been used the loss would have been only half as much, and the steam saved would have equalled 68.61 pounds. This ought to be worth saving.

In the case referred to by H. N. Dawes in the June 7 issue, magnesia was selected in preference to sponge felt, although sponge felt was only 3 to 4 per cent. less efficient than magnesia.

Professor Kent gives a table of coefficients of radiation in which at 115 pounds absolute, that of bare pipe is 684; 2-inch cement composition (probably 85 per cent. magnesia) is 209; asbestos flock 210, and mineral wool 93. Asbestos is a poor heat insulator and must affect any substance with which it may be combined.

R. MCLAREN.

Berlin, Ont.

Questions Before the House

Bad Management

Mr. Sprague's article on "City Council Engineering" in the June 14 issue, is another case of history repeating itself, as per the editorial in issue of May 31.

But why it should be this way is a question not easily understood. Nevertheless it is a fact as hundreds of cases in all parts of the country bear witness. The same thing is true of the purchasing of supplies for the steam plant. The managers in the delusion that they are economizing will purchase what they think is just the proper thing and Mr. Engineer must use it, although in thousands of cases it is not the right thing at all. The result is trouble and needless expense. In some cases, this state of affairs is brought about by good salesmanship and ignorance; in others, it is due to prejudice in favor of a certain machine to such an extent as to be blind to the possibilities of others; all of this amounts to bad management.

A case similar to the one spoken of in the above mentioned editorial, with the exception that vertical boilers were installed in place of horizontal ones, is fresh in my memory.

The old plant consisted of fire-tube boilers in a splendid boiler room. A saving could have been made by utilizing a portion of the old foundations. Those parts which were not used would have interfered in no way; consequently, their removal would have been unnecessary. In spite of all that the engineering force could do or say the management could see nothing but a vertical type of a certain make. This was due, possibly, to the fact that they had once used fire-tube boilers, built by the same firm, with satisfactory results, and took it for granted that the water-tube type was first class. Another item which caught their eye was the attractive first cost. They overlooked the fact that a neat sum could have been saved in freight as they were close to the factory of a company building a first-class horizontal boiler, just the one for the place.

Then there were the old foundations, eight in number, to remove. This was no small task, as they were of concrete and of ample proportions, compelling the use of dynamite and a large force of men. The new foundations were expensive as the boilers extended 4 or 5 feet below the floor line.

The piping was far more expensive and less stable than it would have been with the other style of boiler. The boilers occupied all of the overhead space, it being just possible to house them without interfering with the roof. The management got the idea that the renewal of tubes would be a remote possibility. But the subsequent renewal of tubes and the attendant perforation of the once splendid roof quickly banished this dream.

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

The new boilers were rated at 250 horsepower each, and guaranteed to carry a 25 to 50 per cent. overload, whereas, in thorough tests, using a good automatic stoker, the best they ever developed was 226 horsepower.

The changes made a bad matter worse, for while there was insufficient boiler capacity before, there was less after, to say nothing of the useless expense involved. The management was then prevailed upon to purchase another boiler, but still they seemed to know more than the engineers and concluded to install a surface condenser, a good idea as far as it went. There being a large tank pump in a pit in the engine room they conceived the idea of placing the condenser over the pump, thereby securing the condensing water as it left the pump on its way to the tank overhead, at the same time saving the cost of digging a pit. The bottom of the condenser was brought considerably above the lowest part of the engine cylinders. This arrangement exists still, as far as I am aware.

JOSEPH STEWART.

Hamilton, O.

Installing Globe Valves

I was interested in R. A. Cultra's excellent article in the June 21 issue on "Installing Globe Valves" and I quite agree with his methods of installation with the exception of that for blowoff valves. I wonder if he ever stopped to think of the consequence of the thread stripping off the stem when the pressure is below the disk. If he has two valves on the line, he, of course, would be able to close the other and save his water, but I have seen lots of plants with only one valve to each boiler and none on the line.

For a blowoff valve I prefer an iron-body valve with a heavy cast-iron disk with a babbitt lining which can be renewed at a cost of only a few cents and a few minutes' work when the valve leaks. The pressure should be on the top of the disk.

We have had fifteen 2½-inch valves of this type in service for seven or eight years and never have been bothered by them clogging with scale. One thing about them that appeals to me is that the fireman cannot open or close them quickly enough to damage anything even if he wants to. I have seen so much abuse of blowoff cocks by firemen that I would not accept them as a present if I could possibly get the regular blowoff valve.

C. B. SMITH.

So. Framingham, Mass.

Engineers' Wages

No employer deliberately throws away money which he might put into his pocket. It is evident that many employers do throw away money by employing low-price engineers. These two statements appear to be contradictory, but they are not when we consider that a large number of engineers are employed by men who know nothing of their work, whose only method of judging their engineer's efficiency is by seeing the line shaft turn, and also that, outside of public-service power plants, the total cost of power is likely to be so small a part of the whole expense that a 10 per cent. saving there is lost sight of.

With long-distance power transmission coming into vogue to such an extent, it is easy for an employer to figure exactly what he can afford to pay for his power; he knows what his coal, oil, fuel and outside repairs cost and he can readily tell from his books just exactly what his engineer is worth. If the engineer wants to know himself, he can figure it almost as closely if he has knowledge of the price paid for coal and the price of electric power.

Suppose an engineer in a small plant figures that he is worth $25 per week when he draws $18, what is he to do? If he goes to the "Old Man" with his figures, it is likely that he will be told that all that he has said is perfectly true but that there are a dozen men ready to take his job if he does not want it.

In such a case the employer cannot be blamed if he hires another man at the same price, particularly if the other man proves to be equally as good. What I would like to suggest is a rather novel variety of union and one that will meet the approval of manufacturers and employers.

First, I believe in a union for education. Of such there is a plenty. Next, I

believe in a union for publicity. Of this kind there is none.

If I should try to sell engines by waiting until I had one made and then going up and down the street in my old clothes, calling at one office after another until I found a customer and selling it at his price, I would land in the poor house. I believe that a man who has nothing to sell but his labor and brains should use the utmost diligence in advertising himself. This does not mean bragging; it means that he should keep a daily record of every plant that he handles and keep it in such a way that the cost per horsepower or kilowatt can be told at once for any given time, including all cost for repairs, etc. I believe that a graphic record accompanied by actual figures for proof, turned into the hands of the proprietor, would help matters by giving him a better idea of the actual cost, by calling to his attention the fact that he has a power plant and by showing him whether his engineer is growing more expensive or less so as time goes on. I also believe that another chart and set of figures should be sent to the headquarters of the union so that those who are interested may verify the computations, compare the results with the local market value of a horsepower and advise the engineer either that he has a "cinch" and should "freeze" to the job or that he is working too cheaply and should get more. Other members of the body should also be warned that such and such a job pays so many dollars a week and is worth so much more to any man equally as capable as the incumbent. By a process of education and comparison engineers would ultimately find their level and the plants that can be made to be worth $30-men would get $30-men and the plants that are worth $15-men would get that kind.

When an employer finds himself confronted by an engineer who can prove in cold figures that he is worth $25 and cannot get anyone else whom he dares to trust, for less than that, because others will know that that is what the position is worth, then he will pay $25. On the other hand, if an engineer is getting $20 a week and earning it, he need not be surprised or offended if someone else comes along and says, "Here, I can make that job worth $25 because I can save $5 worth of coal a week," and gets his job away from him by raising the price. Employers are "from Missouri" and must be shown; dollars and cents appeal to them. For one man here and one there to begin making spasmodic reports on the cost of power to their employers would do no good. It requires organization, uniform report cards furnished by the union, etc. It requires, also, full information about every power plant whether the engineer belongs to this organization or not. All this information should be available to every man who operates engines, whether he belongs to the organization or not.

E. F. HENRY.

Worcester, Mass.

I herewith give the scale of wages and hours of service which prevail here:

Engineers, first class, $4 per 8-hour day; engineers, second class, $3.50 per 8-hour day; firemen, $3.15 per 8-hour day; water tenders, $3.35 per 8-hour day; pump men, $3.75 per 8-hour day; coal wheelers, $2.75 per 8-hour day.

Overtime work is paid for as straight time, as is also Sunday work.

I would like to see tabulated data from all of the States. They would be interesting at least.

L. EARLE BROWN.

Roundup, Mont.

In answer to Waldo Weaver, in the May 17 issue of POWER, I will say that I am not in a very large or prepossessing plant. I have charge of two 16-foot by 66-inch return-tubular boilers suitable for 150 pounds working pressure, and one 14x36-inch Corliss engine and all of the necessary appliances of an exhaust-pressure and live-steam gravity-heating plant for drying draining tile and brick.

I do my own firing and repair work and think that I am a practical and capable mechanic. I did the installation and steam-fitting work with my own hands and all of the other work that an engineer might be able to do in a plant of this kind. Everyone knows that brick-yard surroundings are not the most congenial and it is hard to keep out the dust, yet I am not ashamed to have anyone visit my little plant.

The ordinary load is 90 horsepower. It varies, however, from just the friction load to 90 horsepower and sometimes to as high as 150 horsepower for a short time. The night fireman gets $2 per night with comparatively light work and small responsibility and no repair work. My wages are $75 per month with two Sundays off per month, if I can get the work out of the way without working every Sunday. The boilers are cleaned while the plant is in operation during the week, every other week, under my direction and with my help.

My hours of work are nearly 12 hours per day.

LEROY H. WHEAT.

Emmetsburg, Iowa.

Drop in Steam Pressure

In reply to H. E. Satterfield, who under the above caption, in the June 21 number, asks for information in regard to what is a reasonable amount of drop in pressure between the steam pipe and cylinder, there is no doubt in my mind that people seldom appreciate the amount of money lost through having steam and water piping too small. I remember once indicating in Chicago a 1200-horsepower vertical engine. By putting an indicator on the high-pressure steam chest and on the steam header, only 10 or 15 feet away, I found a drop averaging about 10 or 15 pounds, I forget which; the steam pipe was of a size considered ample.

The superintendent of a large mill recently told me that when indicating the low-pressure cylinder of a steam engine, he always used a separate indicator close to the opening on each end. He had previously found that otherwise the instruments read too low, because the low-pressure steam did not travel fast enough through the sizes of pipes ordinarily used. Personally, I never encountered this difficulty, because I have always used two indicators, but I can very well believe that his finding is quite correct.

The cost of labor, brackets, etc., is usually a considerable portion of the total cost of piping installed, and it does not pay to use the smallest practicable size. An even more important matter is that of sharp bends.

WALTER T. RAY.

Spartanburg, S. C.

Cylinder Lubrication

In the June 7 number, Mr. Longstreet tells of feeding a high-grade cylinder oil, costing 35 cents a gallon, into the high-pressure cylinder with a steam pressure of 160 pounds and 85 degrees of superheat. He feeds the same oil into the low-pressure cylinder; the only difference is that but half the quantity is used. The pressure in the low-pressure cylinder is 15 pounds and there is no superheat. Now, either this oil is too good for the low-pressure cylinder with its low temperature and wet walls or too poor for the high-pressure cylinder with its high temperature and dry walls.

In our plant we use an oil costing 90 cents per gallon in the high-pressure cylinder and one costing 30 cents in the low-pressure cylinder, fed at the rate of one-half gallon of each kind per day of 24 hours in an engine 22 and 40 by 48 inches with a steam pressure of 125 pounds and a receiver pressure of from 5 to 10 pounds, according to the load.

A company not far from where I work got a new cross-compound 20 and 36 by 46-inch engine, running at 126 revolutions per minute with a steam pressure of 150 pounds. One day the chief asked me to come over to see the porous cylinder on his engine. When I got there they had the high-pressure cylinder head off. The walls were as dry as though they had never seen oil. But like some of those marine-engine cylinders we read so much about, it was getting along all right without it. I was surprised when told that they were feeding a gallon of oil to it every 12 hours and the same amount

of the same oil to the low-pressure cylinder.

We took off the low-pressure cylinder head and found that the low-pressure cylinder was getting enough oil; in fact, I thought too much.

We put the heads back, started up and fed a good stream of oil to the high-pressure cylinder. When we removed the head again the cylinder was as dry as before. The chief said, "I told you so, she is porous." But as there was no oil on the outside, I could not quite see it. I sent over to our plant and got a gallon of our high-pressure cylinder oil and we started the engine up again and fed our oil at a rate of about two drops per minute. After about an hour's run we stopped the engine and took the head off again. The cylinder walls felt quite oily to the touch.

I got an order for some high-grade cylinder oil at 90 cents per gallon and a box of cigars for not mentioning the "porous" cylinder.

A. W. GRISWOLD.

Adams, Mass.

Ignorance among Engineers

I have read with much interest the article by our "Canadian Cousin" in the issue of June 21 on ignorance among engineers. Ignorance is more serious with the employers than the engineers. The employer often does not know the conditions, for if he did, he would put an experienced engineer in charge and not have a blockhead at the throttle merely to keep down the wage rate. The American engineer is not seeking to put his brothers out of employment but to pass laws which will force employers to hire only such men as are qualified to fill the positions and are capable of operating steam plants in a manner that will insure safety to life and property.

Mr. Leicester states that the installing of water columns without valves in the steam and water connections would not be allowed in British Columbia. This may be true, but he overlooks the fact that under some conditions it is absolutely necessary to have stop valves on the water-column connections, especially in marine service where large Scotch-marine boilers with several fire boxes are used. These boilers are generally provided with several water columns. To shut down one of these boilers in mid-ocean during a storm is liable to result in disaster. It is therefore necessary to have stop valves on both connections to close in case of accident to the gage cocks.

With stationary plants of large size there are usually many small boilers which are shut down often for cleaning and repairs. The mud in the water has choked up the angle valve in the water connection to the column in so many cases that the Massachusetts boiler board has made a law that where valves are used on the steam and water connections to the water columns, straight-way or gate valves must be used. These, too, generally corrode and leak when it is necessary to close them in cases of emergency.

Mr. Leicester states that there cannot be established any certainty of a clear passage for both water and steam by merely opening the drain from the water glass. This is true if there is not a ¾-inch drain to the water column as well as a drain from the glass.

The blowing down of the gage glass and water column depends on the kind of water used. In several plants I have been obliged to blow out the glass every hour, and the column every two hours. I have had a drain pipe to the column plug up in two hours' time so that 125 pounds pressure would not start it until a wire had been punched through, the valve being only slightly open and of the gate type.

I do not see how our "Canadian Cousin" can feel safe in blowing down the water column only once or twice a week. We have a very good vegetable water here, taken from the city supply which comes from a large pond; but under no conditions do I allow the boilers to run without testing the gage glass and water column every four hours. I use the surface blowoff and the bottom blow-off pipes each twice a day. This may seem to some engineers a useless waste of water and fuel, but we find about 1/16 inch of scale every six weeks and this amount of care is required to keep it from accumulating.

R. A. CULTRA.

Boston, Mass.

Location of Throttle

Considerable has been said of late about the proper location of the throttle.

It goes without saying that the natural and most convenient position for the wheel is on the front side, handy to the valve gear. The only reason advanced for placing it elsewhere is that in case of a runaway this would be about the least desirable part of the engine room to visit.

There are several ways of overcoming this undesirable feature. The simplest and least expensive would seem to be to place the throttle wheel on the opposite side of the cylinder and use a bypass valve for handling the engine, keeping this closed when the main throttle is open.

In the case of an ordinary Corliss or similar type of engine, unless the valve gear has been deranged, it would be simply a waste of valuable seconds to attempt to close the throttle as a single sweep of the hand would bring the governor to its lowest position and shut off steam in a small fraction of the time required to wind in the "mile of thread," as one writer put it.

After all, there is only one really satisfactory solution of the problem; that is, install a reliable engine stop with push buttons located in various convenient parts of the room, including, in some cases, the boiler room and basement. When the stop is once installed it should not be kept for an ornament but should be used at regular periods to make sure that it is in working order so that it may be depended upon in case of emergency. With this arrangement not only the dangerous position is avoided but much time may be saved.

LEON ROUNDY.

Concord Junction, Mass.

Boiler Disaster of the Early Morning

I read with interest the editorial in the May 10 issue of POWER on the early morning boiler explosion.

As it seems truly to be a case of unbalanced pressure at the initial opening of the stop valve, the thought suggested itself to me, should not all systems of boiler leads, headers and connections be provided with bypasses?

The inexperienced, and usually it is left to such men to cut in the boilers, seem not to realize the amount of steam that can get through a large stop valve just started from its seat.

For this reason, I would suggest the bypass system. We bypass nearly all other large valves, but, to my knowledge, a bypass has not been used for this particular service.

Since thinking of it, I have looked up the idea in all of the textbooks that were available, but could not find a thing mentioned in regard to the subject.

In view of what was said in the editorial about the heat and pressure stored on one side of the stop valve, and the large condensing area on the other, it would seem that the use of some method of warming up would be commendable practice.

JAMES W. LITTLE.

Fruitland, Wash.

Standard Colors for Station Piping

The article on "Standard Colors for Station Piping," in a recent number of POWER interested me very much.

The increased size and complication of steam plants makes such a system necessary.

The tagging of valves and pipe lines does not fill the requirements, as the tags come off and are lost and they cannot be seen distinctly from a distance or through smoke or steam, and in an emergency nobody will know where anything is because everybody has been depending on tags.

Painting the pipes different colors is not very good as colors do not look the same to all men, or in different lights. A green in daylight becomes a blue in the light of the arc lamps, and a blue changes to black under the same conditions.

When pipes have different colors the men are liable to get into the habit of calling the pipe lines by the colors, without connecting the colors with what is inside of the pipes.

Also, there are so few colors that will wear well in the heat and dirt of a power plant, most of them soon become useless and the expense of repainting the piping is great.

I think that a system of markings should be arranged so that anyone could tell at a glance what is inside of a pipe and the direction of the flow.

All of the important valves should be numbered, not by tags but by figures painted on the covering of the valve body as large as possible and on the side which can be seen the best from doorways or gangways.

The numbers should preferably be painted in black as black wears and shows up well.

An arrow should be placed to one side of the number to show the direction of flow where the other pipe mark does not show. The boiler stop valves need not be numbered, let them be known as boiler stop valves. The valves on the boiler leads to the main header may be numbered from No. 1 up with numbers corresponding to the boiler numbers. All cut-out valves on the main header or on connecting bends between the headers may be numbered from 101 up with numbers running in the same direction as the boiler numbers. The valves leading to the loop, or to the engine leads where there is no loop, may be numbered from 201 up, and so on, as far as it is desired to carry out the system.

The men would soon learn the numbers of the valves and, in an emergency, it would be better to tell a man to close valve No. 304, than to try to tell him to close the stop valve on the loop for No. 4 engine. The probability is that he would be more likely to close the right valve and not shut off the valve for No. 5 engine by mistake.

Where a valve is not in plain sight from the regular passages, there should be in addition to the numbers on the valve, a number on the wall with an arrow pointing in the direction of the valve.

As a suggestion for a pipe-marking system, I offer herewith a chart which was worked out for an office building.

The colors will all wear well and will not change so as to be mistaken. The colors used are red, black, green, brown, white and yellow. The idea is to paint the markers on the pipe as large as possible and where they will show up the best. The point of the mark shows the direction of flow. Where flange marks are needed, and there is no flange where the mark is wanted a band can be put on the pipe of greater width than the other marks. The marks are to be put only where they will be needed: where a pipe branches, in passages where the pipes go through a wall and in the pipe shafts. It may be well to have at least one mark on each pipe in every room.

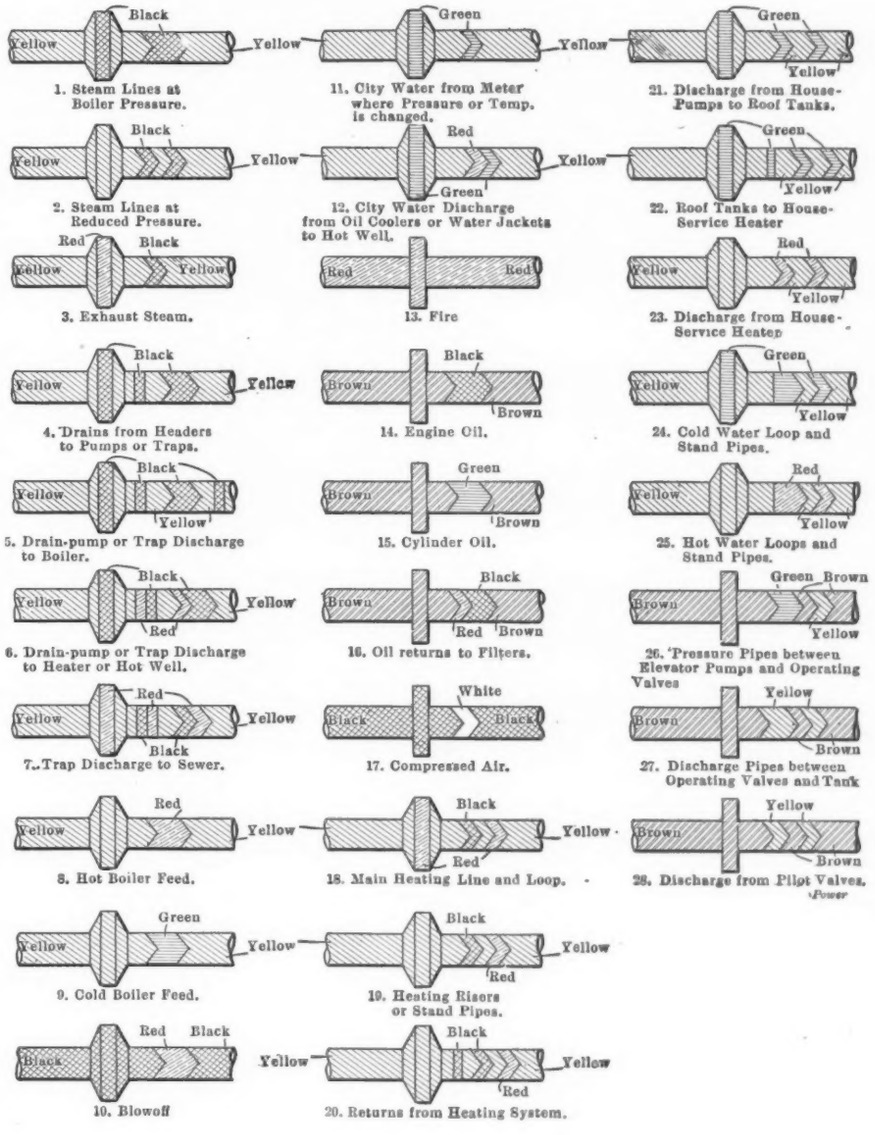
The high-pressure steam, reduced-pressure steam and exhaust-steam lines (Nos. 1, 2 and 3) are simple, and there is no danger of getting them mixed. All drain lines between pipes or headers, and the drain pumps or traps are marked the same as the pipes which they drain with the addition of a narrow black band. This band is in back of the marker (No. 4).

Where the drain pumps or traps discharge to the boiler direct, the pipe is marked the same as the drain pipe with the addition of a black band ahead of the mark (No. 5).

Where the traps discharge to the hot well or feed-water heater the marks are touched with red and black (No. 6).

Where traps discharge to the sewer, the marks are touched with red, ahead of the marks (No. 7). The hot feed water, cold feed water, blowoff and city water pipes (No. 8, 9, 10 and 11) cannot easily be mistaken.

Red lead is the best paint for fire lines if they are of black iron. A great many plants already have them painted so.


1. Steam Lines at Boiler Pressure.
2. Steam Lines at Reduced Pressure.
3. Exhaust Steam.
4. Drains from Headers to Pumps or Traps.
5. Drain-pump or Trap Discharge to Boiler.
6. Drain-pump or Trap Discharge to Heater or Hot Well.
7. Trap Discharge to Sewer.
8. Hot Boiler Feed.
9. Cold Boiler Feed.
10. Blowoff
11. City Water from Meter where Pressure or Temp. is changed.
12. City Water Discharge from Oil Coolers or Water Jackets to Hot Well.
13. Fire
14. Engine Oil.
15. Cylinder Oil.
16. Oil returns to Filters.
17. Compressed Air.
18. Main Heating Line and Loop.
19. Heating Risers or Stand Pipes.
20. Returns from Heating System.
21. Discharge from House-Pumps to Roof Tanks.
22. Roof Tanks to House-Service Heater
23. Discharge from House-Service Heater
24. Cold Water Loop and Stand Pipes.
25. Hot Water Loops and Stand Pipes.
26. Pressure Pipes between Elevator Pumps and Operating Valves
27. Discharge Pipes between Operating Valves and Tank
28. Discharge from Pilot Valves.
Power

SCHEME FOR PIPE IDENTIFICATION

These marks can be put on a large pipe system at small expense, and in the engine room, pipe shafts and around the building they would last for a long time. In the boiler room and basement they would not last so long, but they can be renewed very cheaply. When they are once in place any fireman or handy man can renew them. Charts with pipe marks and explanations should be printed.

C. G. HARDEN.

Chicago, Ill.

Interesting Test of Manning Boiler

In the Manning boiler there is a considerable vertical distance between the lower tube sheet, and the ogee which connects the outer sheet of the water leg to the barrel. This distance is necessary for the location of handholes which must be on a level with the crownsheet. The condition will be evident from an inspection of the sectional drawing, where, however, no handhole is shown, and is described by S. F. Jeter, M.E., in an article entitled "Features of the Manning Boiler," in our issue of February 15 of this year.

To demonstrate the reinforcing effect of a continuous strap riveted to the inside of the sheet extending from the lower edge of the ogee to the top row of stay bolts, hydraulic pressure was applied. The reinforced section showed considerably less distortion than the barrel.

In the water leg it is desirable that thin material should be used for the outer as well as for the inner sheet, to afford flexibility on each end of the staybolts. The connection of the inner and outer sheets by the staybolts reduces the tensile stress on the outer sheet and makes the use of a thin sheet allowable for the stayed portion. In order to strengthen the portion above the stays it is the practice of the Bigelow company to rivet a continuous strap to the inside of the sheet extending from the lower edge of the ogee to the top row of staybolts.

Notwithstanding this construction has shown no distress in service and has been approved by the boiler-insurance com-

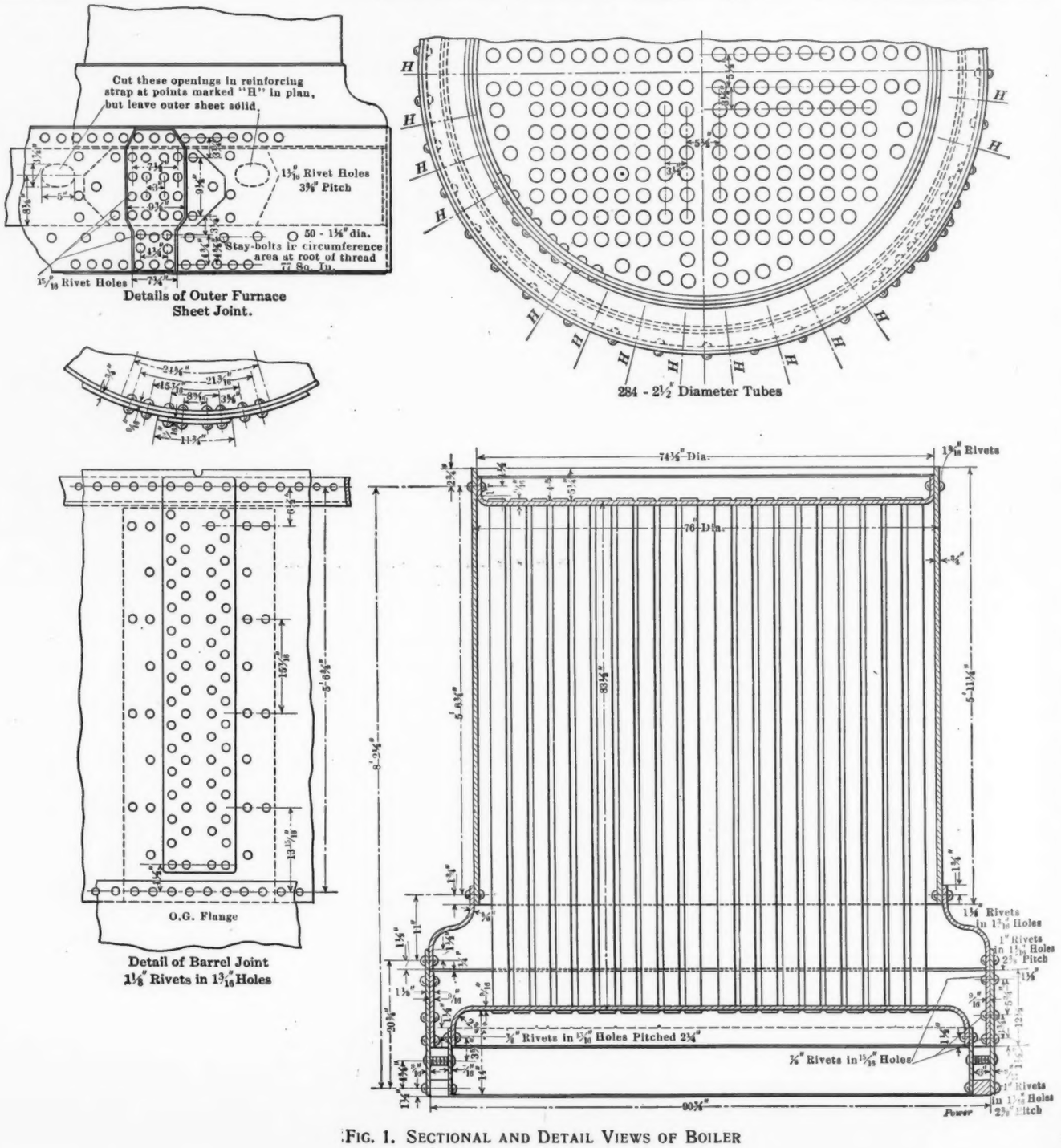

Cut these openings in reinforcing strap at points marked "H" in plan, but leave outer sheet solid.
1 15/16" Rivet Holes 3 3/8" Pitch
50 - 1 3/4" dia. Stay-bolts in circumference area at root of thread 77 Sq. In.
15/16" Rivet Holes
Details of Outer Furnace Sheet Joint.
284 - 2 1/2" Diameter Tubes
74 1/2" Dia.
76" Dia.
1 15/16" Rivets
O.G. Flange
Detail of Barrel Joint
1 1/8" Rivets in 1 3/16" Holes
1 1/4" Rivets in 1 5/16" Holes
1" Rivets in 1 1/16" Holes 2 3/8" Pitch
1/2" Rivets in 9/16" Holes Pitched 2 1/4"
3/4" Rivets in 15/16" Holes
1" Rivets in 1 1/16" Holes 2 3/8" Pitch
90 3/4"

FIG. 1. SECTIONAL AND DETAIL VIEWS OF BOILER

panies and the Massachusetts Board of Boiler Rules, the criticism has been advanced that unless the joint between the plate and this strap is made perfectly tight, pressure can act between them and nullify any reinforcing effect of the strap. A common expression of this criticism is that the boiler so constructed is like a cask with the hoops inside.

To settle the matter beyond question the Bigelow company, at the suggestion of Mr. Jeter, who is their mechanical engineer, constructed the model shown in the accompanying drawing and photograph, being a section out of a full-sized boiler of 225 horsepower capacity, including the lower barrel course and one row of staybolts. In other words, the model is a full-sized 225-horsepower boiler with the bottom portion of the water leg and the top portion of the tubes left off.

This boiler was arranged with gages to measure the distortion in various parts, and on Tuesday, July 12, in the presence of various representatives of the boiler inspection and insurance companies, members of the Massachusetts Board of Boiler Rules, professors from the Sheffield Scientific School, and competing boiler manufacturers and others, it was tested by the application of hydraulic pressure. We hope in a future article to deal more particularly with the various distortions produced as the pressure was applied in increments of 50 pounds. For the present it is sufficient to say that when the pressure got a little above 700 pounds, six of the tubes and a plug which had been screwed in to close the opening between the abutting edges of the shell plates in the butt joint where it is not covered by the outer strap (as is common in making this joint) were leaking so badly as to make it difficult to increase the pressure. When the tubes had been reëxpanded and the plug calked the pressure was run up rapidly to just within 800 pounds, when one of the tubes in the outer row collapsed, opening a considerable outlet in the upper head. Another tube, also in the outer row and nearly opposite, collapsed just before but did not produce any opening.

The essential feature of the test and that which is justifiably gratifying to the makers of the boiler is that the distortion of the reinforced section was very much less than that of the barrel, of the safety of which there is no question. The gage in the middle of the barrel showed that its circumference increased 1.98 inches, while the circumference of the water leg at the center of the reinforcing strap increased only 0.24 of an inch. The distortion of the barrel was thus about eight times as much as that of the construction under investigation. A gage applied just above the staybolts showed no distortion whatever, showing not only that the properties here are perfectly safe but that no effect was produced by leaving off the lower rows of staybolts in the tested boiler.

The tubes were 2½ inches in diameter and of standard thickness, but had been used before. There was no change of shape either of the barrel or firebox section under pressure in the region of the joint. Wooden forms made to span the joint and fit the boiler near it before pressure was applied, fitted equally well during and after the test.

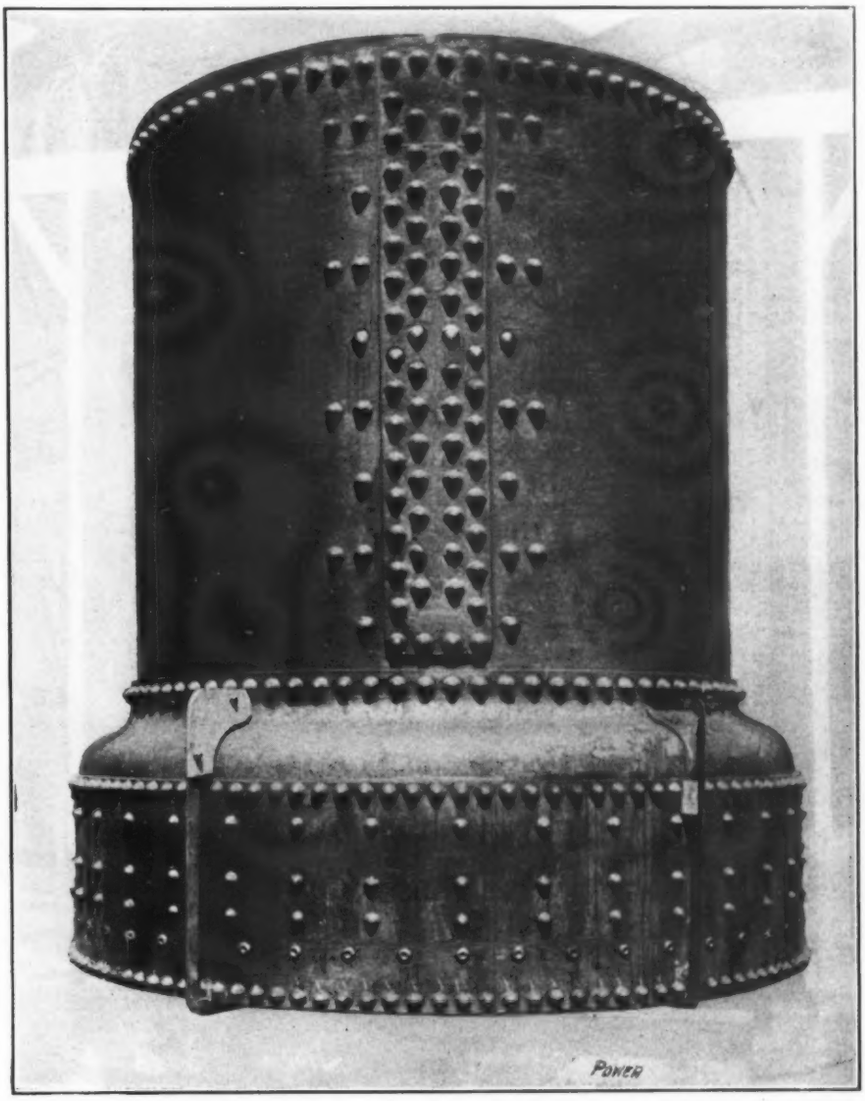


FIG. 2. THE BOILER AS PREPARED FOR TESTING

Unique among the events in which public-utility corporations participate, was a banquet given by the Chamber of Commerce, of Long Beach, Cal., to the officers and executive staff of the Southern California Edison Company at Hotel Virginia, Long Beach.

It was in celebration of the selection by the company of a site on the harbor of this Pacific coast port for a steam-generating plant which will ultimately be one of the largest in the country.

The banquet was attended by about two hundred and fifty citizens. In the addresses expressions of hearty good-will toward the company and a hearty appreciation of what it is doing for Long Beach and southern California, were features that have few parallels in the relations between commercial organizations and corporations.

In describing the proposed plant, W. A. Brackenridge, vice-president and general manager of the Southern California Edison Company, said: "The first building will be of sufficient size to contain two turbo-generating units with a total output capacity of 40,000 horsepower.

"Contracts have been let for a part of the machinery and boilers. These are substantially all of the plans that have been definitely decided upon.

"It is expected that the machinery now under contract will be installed and ready for operation about the first of the coming year."

Tubular Boiler Explodes in Laundry

By F. L. Johnson

A boiler built of inferior stock, carrying four times its safe working pressure, explodes; completely wrecking one three-story building and damaging several others. One man was killed and five other persons were seriously injured.

Just before six o'clock on the afternoon of July 5, as the employees of the Lakeport steam laundry, Laconia, N. H., were preparing to leave for home, the boiler exploded, wrecking the entire structure, which was a three-story building. One man was killed by a large water tank which fell from the roof, and seven other persons, two men and five women, were seriously though not fatally injured by falling timbers and flying pieces of the wreck.

The damage was not confined to the laundry building alone, for the force of the explosion shattered the rear wall of an adjoining brick building, blew out the entire plate-glass front of two stores, wrecked a pool room and a barber's shop. One man was thrown through a plate-glass window and clear across the street, while his wife, standing nearby, was uninjured.

As the work for the day was over, the various outlets for steam were closed and the heat in the furnace and boiler setting was sufficient to raise the steam pressure beyond the safe limit. The safety valve, which has not at this writing been found, did not blow. But it is stated on good authority that it was set at 85 pounds and that it blew freely on the Friday before the day of the explosion.

It is probable that the initial rupture started near the middle of the length of the boiler in the longitudinal seam, as the greater part of the shell sheet comprising the front, middle and a part of the rear course, opened outward and nearly flat, was blown directly through a brick wall parallel to and near the boiler setting. Part of the rear course, which was torn completely around the entire circumference, through solid metal, and the rear head, holding some of the tubes, were driven through the partition into the laundry office and turned through about 90 degrees and lay at right angles to their position in the setting.

Portions of the front were blown down an alley about 200 feet, ricochetting from one side to the other. The front head and the tubes that went with it were carried diagonally to the front corner of the boiler room where they were buried in the wreck of the two floors above.

The boiler, which was built, it is said, by the Lowell Boiler Works, about 15 years ago, was 36 inches in diameter by 9 feet long, was of ¼-inch plates with 5/16-inch heads and thirty-four 2½-inch tubes. The segment above the tubes was stiffened by a flat bar 4 inches wide and ½ inch thick riveted to the head about 3 inches above the tubes.

It is not probable that the boiler was designed for the 85 pounds pressure under which it has been operated for the past ten years.

In the longitudinal single-riveted seams the pitch of the 11/16-inch rivets was 2 inches, giving, if the rivets were of an equal strength with the plate, an efficiency of over 65 per cent. for the strength of the joint.

The first illustration, Fig. 1, shows the wreck of the building under which the parts of the boiler were buried. At the left is the brick wall through which the shell was blown. The photograph, Fig. 2, shows the part of the rear course from which the rest of the shell was torn through solid metal, the front head and five tubes which went with it. The small cut, Fig. 3, is an enlargement of the

FIG. 1. APPEARANCE OF LAUNDRY BUILDING AFTER EXPLOSION

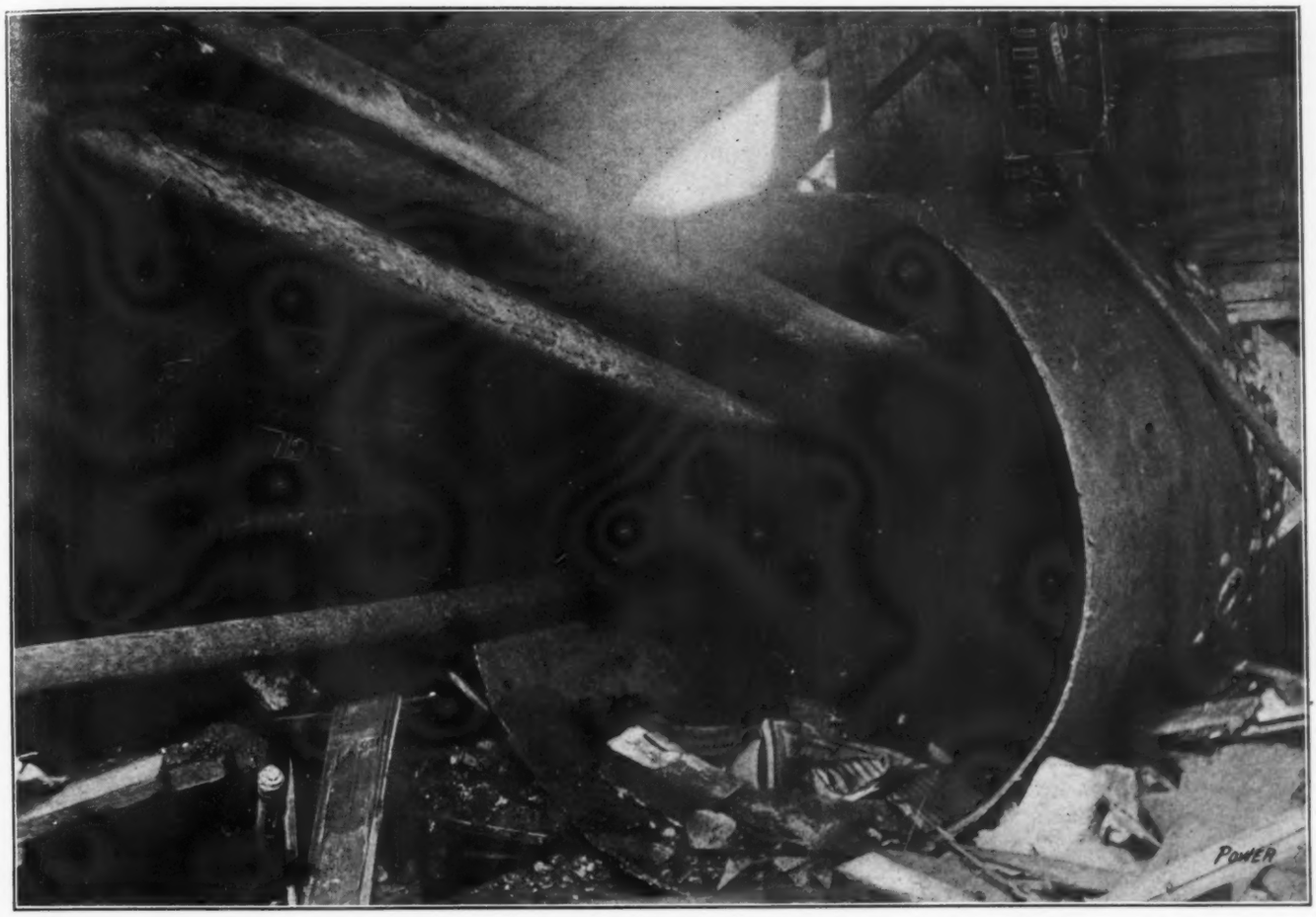


FIG. 2. REAR COURSE AND HEAD TORN FROM SHELL SHEET THROUGH SOLID METAL

fracture of a test piece from the shell sheet which failed at 24,800 pounds stress per square inch.

It was impossible to get a photograph of the sheet which was blown through the walls. But from the exposed edges, however, several pieces were obtained. To get these cutting was unnecessary as with an 18-inch Stillson wrench pieces 6 inches in length were easily broken from the sheet. Test pieces were made from these and pulled apart at the engineering laboratory of Columbia University. The elastic limit was low, the pieces showing no elongation and snapping like glass under the test, some of them having a tensile strength of only 24,800 pounds per square inch.

Though with some justice New Hampshire has been called the dumping ground for condemned Massachusetts boilers,

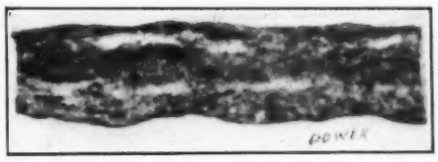


FIG. 3. ENLARGED SECTION OF TEST PIECE WHICH FAILED AT 24,800 POUNDS STRESS

this one had not, like some others which have expolded in the State, been condemned by the Massachusetts inspectors. But it is needless to say that such a boiler would not be allowed to operate under similar conditions in Massachusetts, for it was old and unsafe, built of tank iron and with single-riveted lap longitudinal seams.

There is no mystery about the cause of this explosion. It was a case of simple overpressure. There was no evidence of low water, leaking joints, scale or excessive corrosion. Except for the unwarranted pressure carried at times the boiler had the best of care and the fact that not a single rivet was sheared while the plate tore as readily through the solid metal as along the seam shows like the physical test that the shell plates were of remarkablly poor quality.

Central Station Heating*

By F. H. Stevens

For a number of years after its introduction, little was known as to the proper methods of installing central-heating systems, and to this lack of information a number of failures were due. But today, with the modern methods of construction and management and a knowledge of the different materials used for insulating the distributing mains, many heating plants are operating successfully and are producing attractive returns upon the investment.

It ill behooves the manager of any electric-light or power plant whose station is located within a mile of the business section of a city to ignore the subject and consider district heating prohibitive in his particular case without first getting definite information from some reliable source.

Almost from the first, the advocates of central-station heating have had the opposition of the consulting engineer and the engine builder, and it is only lately that these have been forced to recognize the system as an important revenue producer. The engine builder's objection lay in the fact that it raised the water

*From a paper read at a meeting of the National District Heating Association, at Toledo, O.

rate of the engine a considerable amount, sometimes doubling the steam consumption per kilowatt-hour.

This at first might seem to justify the opposition, but let us carry the investigation a little farther. Assume, for the sake of comparison, that the electric load is 5000 kilowatts and that the prime movers are compound Corliss engines, the manufacturer's guarantee being 20 pounds of steam per kilowatt-hour when operating with a 26-inch vacuum. This would make a total consumption of 100,000 pounds of steam per hour.

Now let us assume that the engines are to be operated noncondensing and exhaust into a heating system, resulting in a maximum back pressure of five pounds; and that the consumption of steam by the engine will be 45 pounds per kilowatt-hour, or a total of 225,000 pounds per hour.

In either case there are 5000 kilowatts of electric current for sale, which at 5 cents per kilowatt-hour would represent an hourly revenue of $250.

In the case of the plant operating with a heating system, we have in addition to the $250 revenue from the sale of electric current, 225,000 pounds of steam for heating, the sale of which at a rate of 60 cents per 1000 pounds would produce $135, making a total revenue of $385.

As to the additional cost with the heating system, it required 125,000 pounds more steam to produce 5000 kilowatt-hours of current. Assuming that the coal costs $2.50 per ton, water 5 cents per 1000 gallons, and firing 30 cents per ton, with an evaporative efficiency of 7 pounds of water per pound of coal burned, the manufacturing cost of steam would be 21 cents per 1000 pounds, or a total extra cost of $26.25. These figures show a net gain of $108.75 in favor of the heating system.

The above is also true of plants of smaller size and the ratio of increase in revenue is approximately the same. The best results are obtained where due consideration is to be given the heating system when selecting the prime mover to be installed.

Ball Bearing Line Shaft Hangers

Among other papers presented at the June meeting of the American Society of Mechanical Engineers was one on "Ball-bearing Line-shaft Hangers," by Henry Hess, an abstract of which was printed in the June 21 issue of POWER. Following is part of the discussion upon this paper which took place at the meeting:

Part of the discussion following the reading of a paper by Henry Hess at the June meeting of the American Society of Mechanical Engineers. The original paper was presented in the June 21 number of POWER.

F. B. GILBRETH—Is there any information regarding the manner in which concrete buildings and so called mill buildings affect ball-bearing hangers? Many engineers believe that the lack of vibration in the concrete building saves considerable cost of maintenance in line shafting, hangers and bearings.

MR. HESS—The relative necessity of frequent realinement in the case of mill buildings as compared with the more rigid concrete buildings, answers itself. That has nothing to do with roller bearings or plain bearings, as such; when a building moves, the other things have to be adjusted.

C. W. BAKER—Do the ball bearings stand the dust present in concrete buildings better than plain bearings?

MR. HESS—If dust is allowed to get into a ball bearing it will be destroyed, as would any other bearing. It is, however, a very simple matter to keep dust out of a ball bearing. As to the effect of dust in concrete buildings, experience has shown that it does not get into the bearing. Regarding lubrication, I might say that we have in our own shops line shafts which have been lubricated only three times in five years. It is not a question of the amount of lubricant but a question of its becoming hard and gummy, which is no fault of the bearings. We have found pale-yellow vaseline to be a good lubricant in certain classes of service.

MR. JACKSON—It is stated in Mr. Hess' paper that the ball-bearing hanger is as safe and reliable at 600 revolutions per minute as at 200, whereas the use of such high speeds with plain bearings is beset with so many difficulties in the way of reduction in size of line shafting, pulleys, drop hangers, etc., as to take it practically out of consideration. I think these difficulties would apply equally to ball bearings.

MR. HESS—There is no reason why a plain-bearing line shaft cannot be run at a high speed, but it necessitates great care in maintenance. You can run a ball bearing at 600 revolutions per minute or at 1600 revolutions per minute and pay no attention to it from year's end to year's end, but I doubt if there is a man present who would be willing to run a plain-bearing line shaft at 600 revolutions per minute without giving it frequent attention with regard to alinement and other features which are liable to go wrong and give trouble.

Proposed N. Y. State License Law

While the laws of New York allow municipalities to enact ordinances governing the inspection of boilers and the licensing of engineers and firemen, no provisions have been made for the operation by competent men of boilers and engines in all the territory not embraced within the limits of a few cities. That this state of affairs is wrong has long been the opinion of the members of the National Association of Stationary Engineers and in an attempt to improve the condition of its members and conduce toward safety in the operation of steam-power plants, the License Committee of the State Association prepared and had presented to the General Assembly at Albany a proposed Engineer's and Fireman's License Law, which embodies the thought of the committee as to what will best serve the interests of the operator and the public.

Features of the bill now before the New York Legislature providing for the division of the State into districts, appointment of chief and district examiners, appeals from examiner's rulings, grading of licenses, etc.

With the usual exceptions of low-pressure heating boilers, agricultural engines, locomotives, boilers and engines under the jurisdiction of the State and of the United States all engine and boilers must be operated by licensed men only. The State is to be divided into districts, each of which will be under the supervision of a district examiner appointed by a chief examiner who is himself to be appointed by the Governor with the consent of the Senate and who shall hold office for six years or until removed for just cause, vacancies caused by death, removal from office or resignation are to be filled in the same manner as provided for in the original appointment.

The salary of the chief examiner is to be $2500 per year and that of the district examiners to be $1800 each.

An applicant for license as engineer or fireman must be an American citizen or must have declared his intention to become such and have had not less than three years' practical experience as engineer or fireman or have served three years as an apprentice at engine, boiler or pump construction and one year in boiler or engine room.

Regular licenses continue in force for one year and may be renewed from year to year without examination.

Three dollars is the fee to be paid for an original license and two dollars for each annual renewal.

All engineers and firemen not included in the exemption clause and operating engines and boilers within the State will be notified by the district examiner to apply for license and will be given sixty days in which to prepare for such examination for license.

Any engineer operating under a local municipal license may upon payment of the regular fee have issued to him a license of the same grade as the local license.

Any person dissatisfied with any ruling of a district examiner may upon the payment of ten dollars appeal to the chief examiner. A jury of five licensed engineers, two chosen by the aggrieved, two by the district examiner and one by the four already selected shall decide by majority vote the justice of the decision of the examiner and in case the ruling of the examiner be reversed the money paid by the appellant shall be returned to him. Five dollars per day will be paid to each member of the jury and their decision will be final.

Four grades of license are to be granted:

Chief unlimited in horsepower.

First class. To have charge of and operate any boiler or boilers and any engine not exceeding 150 horsepower.

Second class. To have charge of and operate any boiler or boilers and any engine not exceeding 75 horsepower.

Third class. A special license to operate any particular plant provided that the owner of such plant makes the application and shows that a duly licensed engineer cannot be procured. Such license may be issued for a term of thirty days and may not be renewed.

Two years' experience in any lower grade is necessary for an examination for the next higher.

The term "have charge" is defined and construed to refer to the person under whose supervision any boiler or engine is operated.

The horsepower of any boiler is rated at ⅓ square foot of grate surface per horsepower for a power boiler, and 1½ square feet for a heating boiler.

Engine horsepower is based on 40 pounds mean effective pressure for a simple engine, 50 pounds for a condensing engine and 75 pounds on the high-pressure piston of a compound engine.

Operation of boilers and engines by unlicensed persons is a violation of the law and both owner and operator are liable to punishment by fine or imprisonment or both.

Marine engineers holding United States license may be given examination and granted a license of the same relative grade as the one held.

Any engineer who has for three consecutive years operated any plant may be granted a license of the grade required for such plant without examination.

Clean and Near Clean Boiler Tubes

It is of course well known that scale on the heating surface of boiler shells or tubes reduces the heat-transmitting qualities, but of the extent of this effect little is actually known.

Along this line the experience of a central-station engineer may be of interest.

In the boiler room of a public-service corporation there was a light coat of scale over the inner surface of the tubes of the 400-horsepower water-tube boilers. It was not thought that the thickness of the scale was enough to make any measurable difference in the efficiency of the boiler and to prove the truth of this thought a series of tests was made. Two sets of conditions obtained in the plant. One in which for a great part of the day the boilers were worked below their rating and the other where they were forced to near the limit of steam-producing capacity.

Except for the difference in heat transference due to the presence and absence of internal scale the conditions were as nearly identical in all of the tests as possible.

The results though not exactly as expected were of great value, showing in a marked manner the difference in heat-transferring qualities between clean and near clean boiler tubes.

In the last line of the report of the test given herewith will be found the summary which speaks for itself.

RESULTS OF TESTS SHOWING INFLUENCE OF SCALE.

Coal. Eight parts No. 3 buckwheat One part soft	Ordinary Firing.		Forced Firing.	
	Before Internal Cleaning.	After Internal Cleaning.	Before Internal Cleaning.	After Internal Cleaning.
Hours run	5½	5½	5	5
Water used	55,661	92,015	89,981	114,965
Water evaporated per hour	10,120	16,730	17,996	22,993
Equivalent evaporation per hour	10,767	17,802	19,204	24,466
Average horsepower	312	513	558	709
Coal burned, total	9,670	12,945	14,830	16,875
Coal burned per hour	1,760	2,354	2,966	3,375
Pounds water evaporated per pound of coal as fired	5.75	7.11	6.00	6.81
Equivalent water evaporated per pound of coal	6.12	7.56	6.47	7.25
Pounds of coal burned per square foot of grate	11.6	15.60	19.7	22.4
Average steam pressure	175	180	180	180
Average steam temperature	493	467	531	483
Average temperature at gauge pressure	378.8	379.3	379.3	379.3
Degrees of superheat	114	87.7	151.7	103.7
Average flue temperature	492	457	608	509
Average feed water temperature	202	202	200	202
Average room temperature	70	79	69	84
Average temperature of air supply	56	66	56	69
Average air pressure in ash pit	0.24 inch	0.35 inch	1.10	0.85
Flue draft	0.50 inch	0.45 inch	0.50 inch	0.40
Average price of fuel per ton as fired	$1.772	$1.772	$1.772	$1.772
Cost to evaporate 1000 pounds of water (cents)	12.99	10.59	12.44	10.97

What He Wanted

Years ago an old lumberman, who had made a comfortable "pile" in the lumber business in Wisconsin, decided to put up a new mill near Marinette. For the engine he went to Milwaukee and this was how he specified what he wanted:

"Now, Mr. Reynolds, I don't care whether the engine has paint on it or not, but what I do want is an engine which will stand up to its work and have a good healthy exhaust."

That time-worn maxim, "look after the little things and the big things will look after themselves," can find no better field for application than in the engine room.

Inquiries of General Interest

Heating Surface and Boilers

How is the heating surface of tubular and water-tube boilers calculated?

J. C. S.

By finding the area of all the surface which is exposed to the hot gases of combustion on one side and covered by water on the other. In all tubes the inside area is taken as the heating surface.

Does Keying Alter Rod Length?

I have a connecting rod in which the keying is done by wedge blocks, as shown in the sketch. Does keying alter the length of this rod?

J. I. C.

If the wear at both ends of the rod is equal, the length will not be changed by keying. But if the wear is greater at one end than at the other, the length of the rod will change every time it is

keyed. Suppose wear to take place at the crosshead end of the rod, which in the sketch is at the right. It is seen that the movable half of the box must to take up the wear travel toward the end of the rod. This would carry the crosshead pin further from the crank pin and thus lengthen the rod. If wear takes place at the crank end, keying will bring the crank and crosshead pins nearer together and thus shorten the rod.

Safe Pressure on Stayed Surfaces

In a 60-inch boiler the distance from the tubes to the top of the shell is 23 inches. There are 10 stays, each good for a working stress of 6000 pounds. What is the safe working pressure of the head?

E. L. R.

The area supported by the stays is 668 square inches or 66.8 square inches for each stay. As the stress on each stay must not exceed 6000 pounds the safe working pressure on the head will be as many pounds per square inch as 66.8 is contained in 6000, or 89.82.

Valve Setting

How is the valve on the Armington and Simms engine set?

T. O.

In this engine as in all shaft-governed engines, the valve is set by lead. That is, the valve is given the proper lead at each end of the stroke. In this type of engine, beyond seeing that the valve stem is kept at the right length, the operator has no control over the valve setting.

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Universal Leaks in Boiler Seams

If you had a boiler, carrying high-pressure steam, and you moved it into another building and used it for heating purposes at a low pressure of steam and in the moving you did not strain the joints, yet the joints leaked, but before moving they were tight, how would you account for it?

C. J. P.

Such an occurrence in ordinary boiler operation is so improbable that only a thorough investigation of all the conditions of setting and operation would reveal the cause.

Overhead Heating Coils

I wish to heat my shop with exhaust steam in overhead pipes. Can you give me any rules for doing it?

F. A. H.

The heating rules used by engineers provide for a certain ratio of heating surface to cubical content heated. This varies from 1 in 40 to 1 in 200 or more, according to the size of the room.

For a well built shop 1 in 150 is a fair ratio. The coils should not be less than 1¼-inch pipe and should be far enough from the ceiling to allow a free circulation of air around them. All the coils should have an angle to provide for unequal expansion and should have a pitch of 1/16 to ¼ inch per foot of length for drainage.

Grate Surface and Cylinder Volume

How many square feet of grate surface burning 15 pounds of coal per square foot per hour will be required to supply steam at 35 pounds pressure to an engine 5 feet in diameter by 11 feet stroke, making 20 revolutions per minute with ⅝ cutoff.

W. B. R.

The volume of steam used per hour will be

$$5^2 \times 0.7854 \times 0.625 \times 20 \times 60 \times 22 = 323{,}977.5$$

cubic feet. For condensation clearance and leakage this should be increased 50 per cent. or to 485,966.25 cubic feet. One cubic foot of steam at 35 pounds gage pressure weighs 0.1198 pound, and

$$485{,}966.25 \times 0.1198 = 58{,}198.75$$

pounds. If one pound of coal evaporates eight pounds of water, 120 pounds will be evaporated per hour for each square foot of grate and it will require as many square feet of grate as 120 is contained in 58,198.75 or 485 square feet.

Chief Requisites for Boiler

What are the chief requisites of a boiler?

S. B. R.

It should be capable of developing its rated horsepower with easy firing, a moderate draft and average fuel, and in cases of emergency permit of being forced to at least 50 per cent. above its rating.

Copper and Brass Pipe

Where should copper or brass pipe and fittings be used in a modern power plant?

A. B. E.

Copper pipe should not be used at all. Brass pipe and fittings should be used for the feed-water line and in all small unions brass is preferable.

Location of Storage Batteries

I would like a few suggestions on the placing of storage batteries and method of finding proper number of cells.

H. L. L.

Storage batteries should be located in a room separate from everything else, to prevent damage to other apparatus by the acid fumes. The room must be unusually well ventilated and should be kept at a fairly uniform temperature of about 60 to 75 degrees if possible.

The total number of cells in a battery should be 0.54 × the voltage required; thus, for 110 volts, use 60 cells; for 240 volts use 130 cells, and so on. Some of these must be "end cells," to be cut in and out during discharge and charge. If you use an automatic booster, then the number of cells need be only 0.4 × voltage.

Speed of Piston and Crank Pin

Does the crank pin of an engine travel faster than the piston and if so how much and why?

C. M. E.

The crank pin travels over the semi-circumference of a circle in the same time that the piston covers the diameter. The semi-circumference of a circle is 1.5708 times the length of its diameter and the average speed of the travel of each is as 1 to 1.5708.

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Power and The Engineer

Editorial

Boiler Explosions

Steam-boiler explosions in this country occurring at the alarming rate of about two for every working day of the year furnish more than justification for continued, but thus far futile, appeals to the legislatures of the several States and to Congress for the enactment of compulsory boiler-inspection laws.

In most of the States a boiler of any quality of material or degree of workmanship may be installed anywhere and may be operated by men of any or no degree of intelligence or experience.

In the matter of roads, bridges, water supply, contagious diseases and in a thousand and one other matters affecting the safety of life, limb and property, society protects its members. If a man or a corporation should seek to establish a powder mill in the heart of a thickly settled community the measures taken to prevent it would be neither uncertain nor dilatory. If a man should be found suffering from a contagious though not necessarily fatal disease, such as smallpox or yellow fever, his isolation would be immediate and complete.

But a boiler with its possibilities of destruction on a par with those of the powder mill and exceeding those of a polluted water supply or a victim of contagion may be placed without a single protest where men, women and children are thickest, and with its operation and upkeep intrusted, as is all too frequently the case, to one utterly unfit, its ultimate failure is the surest thing on earth.

When the state of affairs existing in this country is compared with that in England, it becomes disheartening and this feeling can only be emphasized by a like comparison with the records from Germany, where in the thirty years ending with 1907 there were in the entire empire, both on land and sea, seventy-two fewer boiler explosions than took place in the United States in the single year of 1909, while for the whole period, there were more than eighteen times as many failures in the United States on land alone as in Germany on both land and sea, and the number of fatalities was in still greater proportion, being more than twenty-seven to one.

Against the United States there is, in the matter of preventable boiler explosions, a terrible indictment which demands action on the part of those responsible. Complete immunity may not perhaps be possible, but, going abroad again for ways of doing things that are better than the American ways, it is found that in Manchester, England, the Steam Users Association has not in the fifty years of its existence lost a life or a boiler from a preventable accident.

This shows the possibilities of intelligent inspection in Great Britain and it is highly probable that the same exercise of brains and common sense in the United States would be productive of equally good results.

Flywheel and Pulley Rims

It would be interesting to get statistics at the present time which would show the relative mortality of flywheels and pulleys during the past ten years as compared with similar figures for the twenty-five years preceding. Flywheels do burst occasionally now, as any self-respecting wheel will do if run at a sufficiently high speed. It would seem, however, that these accidents should be less numerous as more care is certainly taken than heretofore in the design of the rims and rim joints for large wheels.

Previous to 1895, most cast-iron flywheels were made with flanged joints in the rim midway between the spokes, with a strength much inferior to that of the remainder of the rim. The designers of such wheels seemed to lose sight of the fact that the rim was subjected to a bending moment between the rims in addition to the ordinary centrifugal tension. James B. Stanwood and Prof. Gaetano Lanza were among the first to point out the nature of the stresses in the wheel rim and the presence of a dangerous bending moment at the rim joint. Experiments made by Professor Benjamin at the Case School laboratories verified the theories proposed and showed that a rim joint having an internal flange frequently had a resistance of less than one-fourth that of a solid rim. While cast-iron pulleys with whole rims frequently attained speeds before bursting of more than 400 feet per second, wheels with flanged joints failed at less than 200 feet per second. Whether as a direct result of this discussion and these experiments or not, a change in wheel design soon began to develop until at the present time we find very few flywheels having this type of joint. Where the flanged joint is used, it is now placed directly over the arm.

The gradual decline in belt transmission and the prevalence of electric generators has reduced the number of wide thin rims and brought about the introduction of the rim having great depth and little width, one which is better adapted to resist bonding and which can be joined by links or tee bolts so as to give a comparatively high efficiency. Hollow rims with reinforced joints can be made to have a theoretical efficiency of 100 per cent. Such have not, however, been tested to destruction.

Although flywheels are the principal offenders in power-house accidents, high-speed pulleys have also given more or less trouble. The solid-rim pulley, whether of steel, wood or cast iron, is perfectly safe at all ordinary speeds. The general introduction of the split pulley on shafting has brought about some bad designs and poor construction. This is particularly noticeable in the ordinary steel-rim pulley where the rim is parted midway between the arms and fastened by light ordinary lugs riveted to the rim and joined with small bolts. These joints possess almost no resistance to bending and cause the wheel to fail at comparatively low speeds.

The difficulty with wood pulleys is the method of attaching the arms to the rim, and failure usually occurs at this point.

Balance weights are another source of trouble in all kinds of high-speed pulleys. The washer of cast-iron bolted or riveted to the inside of the thin cast-iron rim promptly shears its way to freedom and frequently reduces the strength of the wheel to about one-fourth what it should be. The wrought-iron slugs which are frequently used for balancing wooden pulleys have much the same peculiarity and are usually the initial cause of rupture.

Whether we have reached the limit of speeds in rotating machinery remains to be seen. If any further increase is desirable it will be necessary to pay more careful attention to some of these peculiarities of wheels and pulleys. A linear speed of 200 feet per second should be safe for any solid rim, whether of wood or iron, and half this speed should be perfectly safe for all pulleys whether having jointed rims or not. There are, however, many wheels running today which would be in serious danger if run at the latter speed.

Some Weird Definitions

At the recent convention of the National Electric Light Association, there was presented a report on terminology by a committee composed of men who ought to know better. Among the injudicious changes and obscure definitions recommended were the following:

"Corrective Motor," instead of "rotary condenser"; meaning a synchronous motor operated with an overexcited field to improve the power factor of a circuit carrying an inductive load.

"Feeder"; restricted to power supply, instead of being applied to every circuit in which the volt-amperes are the same throughout its length (ignoring the drop in the circuit wires).

"Reactance Coil," meaning "a coil for producing difference of phase or for eliminating current."

"Quarter Phase" instead of "two phase."

It is regrettable that such an important subject should have been given the inadequate consideration indicated by the report.

Specialization

The present tendency of the industrial world is toward specialization of work and knowledge. This holds true through the various spheres of employment. The manager of a large engineering enterprise is not necessarily a man of vast knowledge, but is a specialist in the methods of organization and in the ability to obtain results through other men; just as much as the electrical engineer is a specialist in laying out the electrical equipment of a power plant, or the expert fireman is, in getting the most steam from a pound of coal.

This specialization, while tending to narrow one's field of application, nevertheless promotes a higher efficiency in the individual, and if taken advantage of, increases a man's worth to his employer. Of course, leisure hours should be devoted to the broadening of one's intellectual field and to the improvement of social conditions, but the working hours should be devoted to seeking the depths of that particular industry which a man has selected as his life's vocation.

However, one should guard against becoming a machine during working hours. It pays to keep alert every moment of the day, and if anything new or out of the ordinary is observed a mental note of it should be made, or, better still, it may be jotted down in a notebook for future reference. *Nothing is worse than neglected opportunity.*

Brooding over low pay and long hours does not improve conditions, but, like all worry, incapacitates a man for better work. He should not get discouraged if his superiors do not agree with him. It should be an incentive to determine whether the fault is his or theirs. If found to be the former, he should have the courage to see his shortcomings and set about to remedy them, keeping in mind that genuine satisfaction is attained only through honest effort.

A man should become an expert in his work, however simple or complicated it may be, as only an expert enjoys his work fully. To arrive at this stage of proficiency, it is necessary to patiently and intelligently master the details of the work, understand the principles, not being satisfied that a thing is so, but always anxious to know why it is so, accumulate experience, train the memory and improve the methods; and before long he is a proficient worker, invaluable to his employer and ready to look with pity upon the other fellow who started out with equal opportunities, but who has wasted his time from a half-hearted discharge of duty and lack of ambition.

A Worn-out Delusion

Whether or not there even existed any foundation for the absurd belief that a manufacturer can prevent his competitors from knowing what he is building we do not know, but we do know that there is not a shred of justification for that belief now. Within the last few years we have repeatedly had the experience of being unable to obtain permission to publish detailed descriptions of new apparatus or machinery because the manufacturer did not wish to give his competitors the "advantage" of ascertaining what his constructional details were; in almost every instance we have found that the principal competitors had complete working drawings of the sacred details within a few weeks after the first machine was completed.

The worst case of this kind that we recall at the moment was that of a gas-engine builder who refused permission to publish details of a new valve gear and admitted at the same time that he had in his possession complete blueprints of all the principal competing engines, and had obtained them almost as soon as they had been issued. Just why he considered himself so much smarter than his competitors in the matter of stealing blueprints, we never learned.

As a matter of cold fact, pending patent applications are the only valid excuse for withholding from publication the description of anything new. When there is no element of this kind involved, a manufacturer's attempt at secrecy almost always indicates either that he is pitiably small-minded and conceited or that he is afraid to submit his designs to the critical consideration of the engineering public.

The law as to the relation between heat and mechanical energy has been violated many times recently, for in our experience every increase in heat was accompanied by a corresponding decrease in energy.

Boiler explosions are getting to be about as common as thunder showers.

There is a great difference between the technical journal of today and that of twenty-five years ago. If you do not think so, compare your latest copy of POWER with that for the corresponding month of 1885.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

Naylor Patent Vortex Steam Separator and Receiver

This device fulfils the office of separation of entrained water from steam, preventing loss in the cylinder from the particles of water, which abstract heat from the cylinder walls of the engine, thereby reducing its economy and power.

This separator is constructed with very large volumetric capacity, which greatly increases the available working pressure at the engine by storing a large volume of steam adjacent to the point of use.

The velocity of the steam in the pipe is thereby lowered, reducing its friction as well as lessening pulsations of the current which cause pipe vibrations. The action of the steam in entering the separator is as follows:

FIG. 1. VERTICAL RECEIVER SEPARATOR

Steam enters a series of four stationary buckets having tangentially curved blades and curved bottoms. The effect of these blades of double curvature is to deflect the steam from the axial line of the pipe and set it revolving freely and at great speed in a circumferential path at right angles.

The cloud of moist steam and entrained water shown in the sectional views of the separator illustrates the whirling condition occurring in the separator.

FIG. 2. VERTICAL RECEIVER SEPARATOR FOR COMPOUND ENGINES

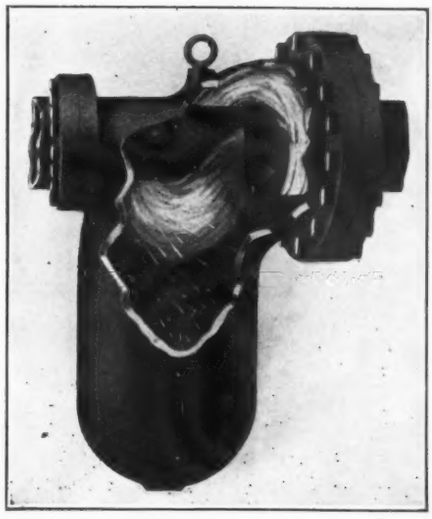


FIG. 3. HORIZONTAL RECEIVER SEPARATOR

At the center of the separator there is an extended pipe from the outlet, which takes the dry steam from the vortex of the whirl, the point at which it is of the driest possible character.

A diaphragm plate, with circumferential openings and interposed diagonal lips, permits the entrained water to pass to the lower space of the receiver where it passes out through a drainage opening.

The diaphragm plate divides the interior of the separator into two distinct chambers, the upper one being the whirling or separating chamber, while the lower one is a still chamber to receive and hold the water to be drawn off.

This separator will carry a large amount of water, but ample provision should be made to get rid of the normal flow of water as well as any extraordinary quantities which may come over from the boilers due to priming or other causes.

These separators are built of any capacity and are made both in horizontal and vertical types by Hewes & Phillips Iron Works, Newark, N. J.

Improved Tomlinson Type "C" Condenser

Since the description of the Tomlinson type C condenser in the March 22 issue, an important improvement has been made in the method employed to build up a vacuum when starting, or in case it should be lost when the turbine is running.

The Tomlinson type C condenser is supplied with two centrifugal pumps mounted on the same shaft and driven by a direct-connected motor or small steam turbine. The larger pump removes the water from the condenser and discharges it into the hotwell, while the smaller one takes water from the cold well and discharges it through a specially designed air-ejector nozzle to the hotwell, the latter acting in the same manner as a dry-air pump.

The manner of forming the vacuum on starting, or in case of loss of vacuum with this condenser, as improved, is accomplished by turning the discharge from the air-ejector pump into the main injection line between the condenser and the main injection valve, through a connection provided for that purpose and shown in the accompanying Figs. 1 and 2. This pump is of ample capacity to furnish the necessary water to form sufficient vacuum to lift the water from the cold well through the main injection line which enables the vacuum to be formed with a full load on the steam unit without shutting steam off the condenser or interfering with full-load conditions.

As the wet-vacuum pump and air-ejector pump are on the same shaft and run by the same motor, any failure to remove water from the condenser will cut off the forced injection supply and eliminate all danger of flooding the system. Furthermore, it makes an arrangement entirely self-contained and independent of any outside source of water supply, thus reducing the auxiliaries to a minimum.

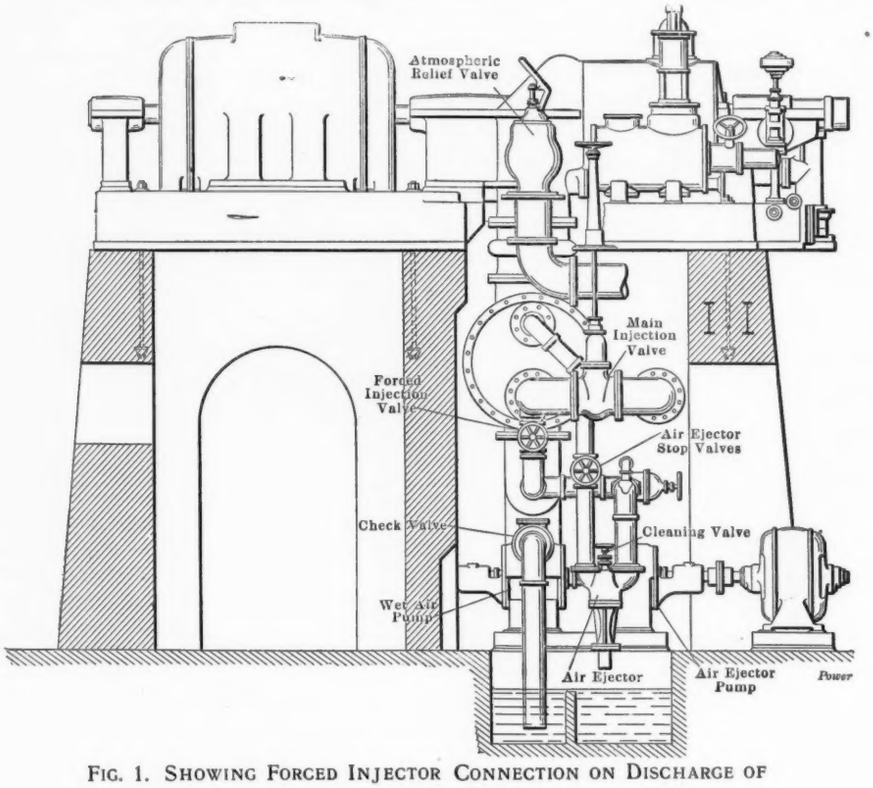


FIG. 1. SHOWING FORCED INJECTOR CONNECTION ON DISCHARGE OF DRY AIR PUMP

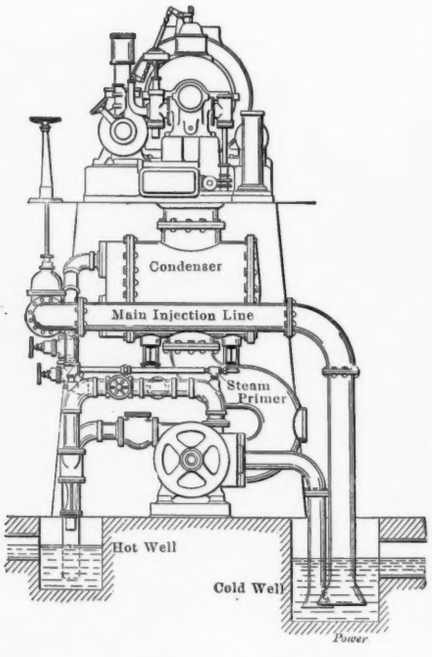


FIG. 2. END ELEVATION WITH CONNECTION SHOWN IN DOTTED LINES

The Harrington Automatic Stoker

The tubular-boiler proposition is one which gives considerable trouble when the question of automatic stokers is being considered, as plants having this type of boiler installed are frequently placed in low-ceiled, inaccessible locations, where deep excavations for ashpits are impossible, or room in front of the stoker is limited.

It was with these particular conditions in mind that the stoker illustrated herewith was developed, and the apparatus has been designed to meet the requirements for an automatic arrangement for burning coal in the smaller boiler installations. This stoker consists of a series of grate bars set at a slight incline to the horizontal, and extending from front to rear of the furnace. The rear ends of all of these bars are supported by a transverse, vertical, adjustable beam, and it is the position of these fixed bars which determines the normal grate surface. The other half of the bar is extended forward to include a yoke in which slides an eccentric block. The eccentric blocks include eccentrics on a transverse shaft, Fig. 1, which is the main drive shaft of the stoker. This shaft is operated by means of a train of cast-steel spur gears securely babbitted in the side frame of the stoker and are operated from a line shaft supported on the boiler fronts, through a sprocket chain having a maximum speed of 100 lineal feet per minute.

The forward ends of the bars are covered by a dead plate which extends the full width of the stoker and acts as a bottom to the coal hopper and a surface upon which a reciprocating pusher may travel. The hopper is designed, in connection with the pusher, so that at each stroke of the latter a certain variable amount of coal can be pushed onto the dead plate. The strokes of the pusher are made with sufficient frequency so

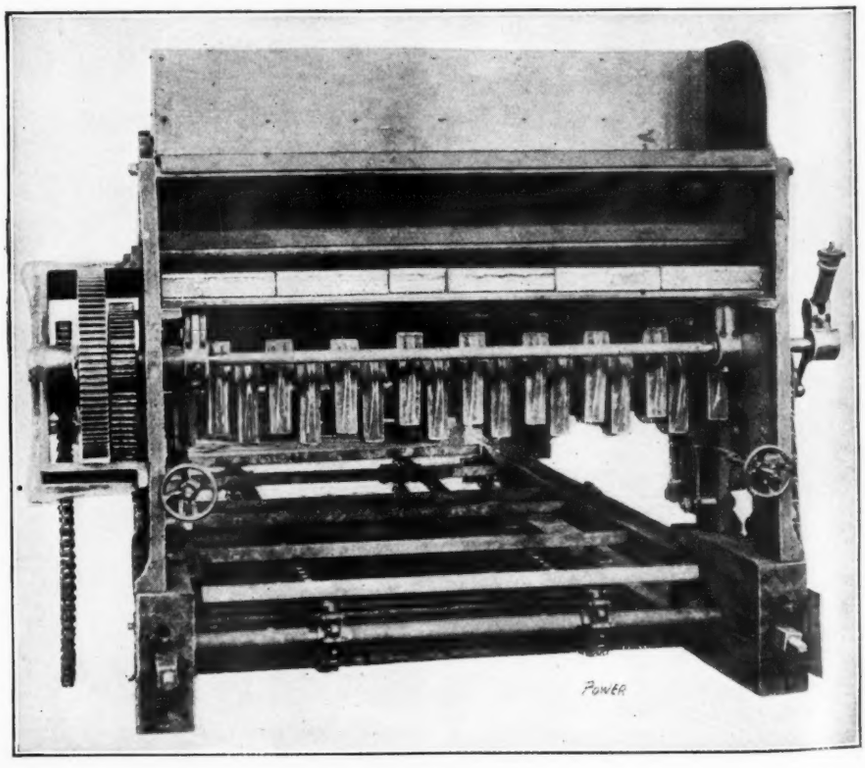


FIG. 1. FRONT VIEW OF HARRINGTON STOKER

that the flow of fuel across the dead plate and onto the grate bars is reasonably constant. During the progress of the fuel over the dead plate it is subject to the heat of the fire and becomes stationary while the bar is returning below the normal grate surface.

As the fuel progresses through the furnace its volume diminishes and becomes more and more porous, requiring

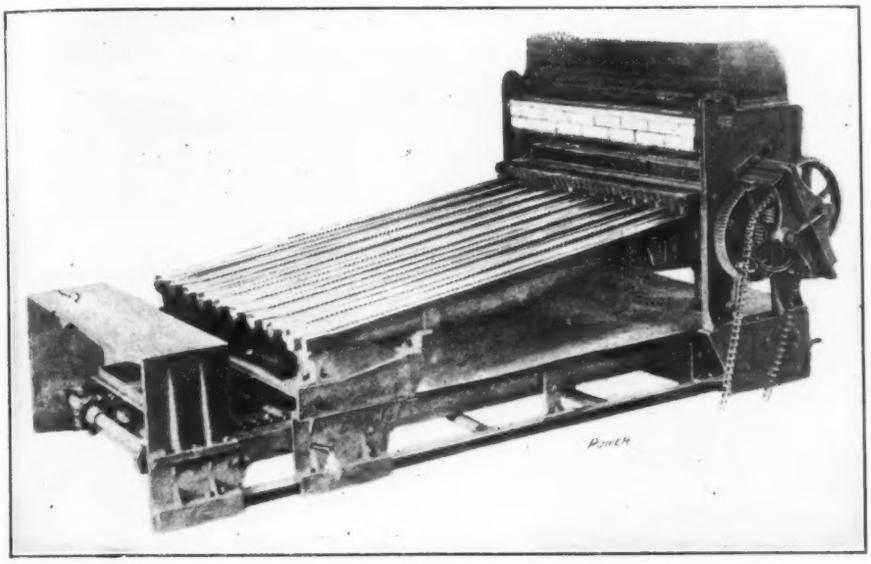


FIG. 2. SIDE VIEW, SHOWING DRIVING GEARS AND ARRANGEMENT OF GRATE BARS

ignited and partially coked. The movable bars operated by the eccentrics previously mentioned can be moved either in parallel or one-half of them can be moved forward while the others are reless motion to the fuel bed. This decrease in motion is obtained by allowing the back end of the bars to slide horizontally on their rear support as indicated in Fig. 2. A comparatively dense

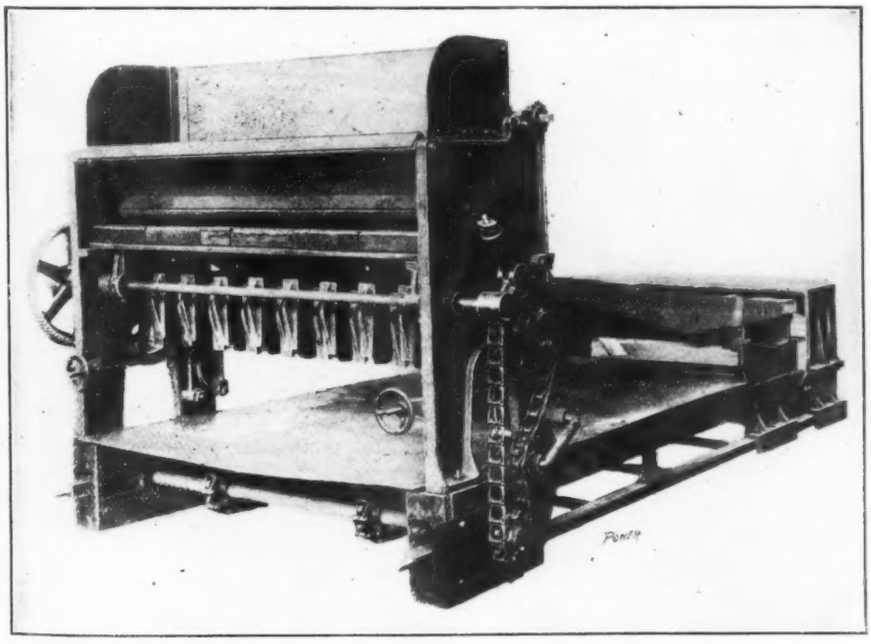


FIG. 3. SHOWING CHAIN DRIVE TO ASH DRAG.

turning, according to the character of the fuel being used. The effect of this upon the fuel is to move it slightly forward at each revolution, depositing it upon the fixed bars, which under the influence of the slight incline and the resistance offered by the fuel, hold the fire about fire at the rear of the stoker is thus effected.

As ordinarily supplied, this stoker is provided with a mechanism for carrying the ash to the front of the setting, where it is accessible and easily removed by hand. The ash drag renders it unnecessary for a deep excavation under the boiler. The depth of the ashpit can be as little as 3 feet if necessary, which will be sufficient to contain the ash for a period of several hours.

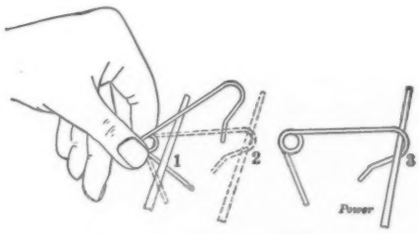
These stokers are built in five sizes in width, ranging from 3 feet 9 inches to 6 feet 2 inches, and are made in two lengths of grate bar, the standard being 7 feet in length, and the other 5 feet. The 5-foot bar is used where excessively small grate surfaces are required, the minimum possibly being 19 square feet.

The Harrington stoker is manufactured by the Green Engineering Company, Commercial National Bank building, Chicago, Ill.

Trill Indicator Hook

A handy device, known as the Trill "Catch-em-quick" indicator hook, made by the Trill Indicator Company, 34 East South street, Corry, Penn., is shown in the accompanying illustration.

It is simple and efficient, and renders the operation of connecting the indicator cord to the standard on a crosshead a



TRILL INDICATOR HOOK

very simple matter, even though the engine may be running at 400 or 500 revolutions per minute.

Its operation is simple, as shown. The loop of the hook is held between the thumb and index finger, allowing the pin on the standard to strike the straight part of the hook when it is within about one inch of the end of its travel. Connection is made instantly without danger to either instrument or operator.

The largest field for future evolution in power transmission is toward high-voltage direct current. Its advantages over alternating current, considering the line alone, would be very great. The effective voltage would coincide with the maximum, and the insulator requirements would be reduced 30 per cent. The number of conductors would be reduced to two at most, and possibly one with grounded return would be satisfactory. Line-charging current and self-induction would not exist and the question of power factor would be eliminated. The whole problem of power transmission would be vastly simplified and costs would be reduced for construction.

Instruments for Alining and Leveling Shafting

Figs. 1 and 2 show a special architect's level and a portable target with self-adjusting jaws for gripping shafts which are being put on the market by the Kinkead Manufacturing Company, 7 Water street, Boston, Mass. These instruments are used for leveling and alining shafting.

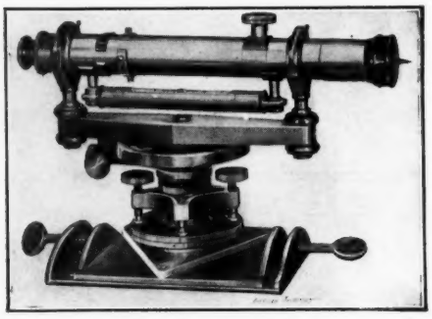


FIG. 1. SPECIAL LEVEL

Fig. 3 shows the instrument where the target is hung from a 1-inch shaft at the driven end and moved along to a 4½-inch shaft at the driving end, which is accomplished without altering the target.

In Fig. 4 is shown the shafting hanging from a post or beam, with an obstruction under the center of the shafting. In such a case the portable target is hung on the shaft and adjusted free from obstructions, as shown, using a counter-

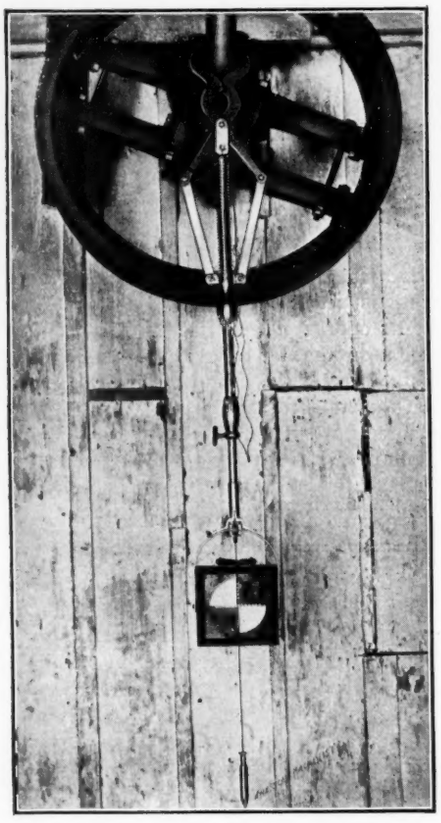


FIG. 2. THE TARGET

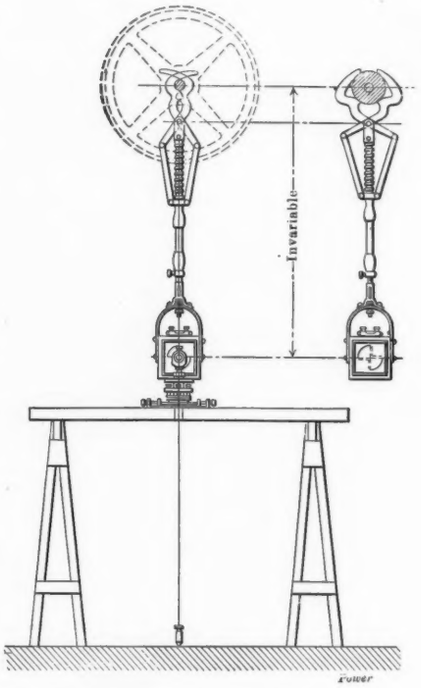


FIG. 3. VARYING SIZES OF SHAFTING WITHOUT CHANGING CENTER OF THE TARGET

weight *A* on the offsets to hold the target down. Then the target is hung on the end of the shaft from which the operator is to handle the opposite level. It is leveled accurately and made plumb from the pin central over the target to the floor, after which the point is marked and the target moved 12 inches. Another mark is made and a line is drawn between the two points. The architect's level is then brought into use.

Fig. 5 shows the method of using the device where the shafting is heavy and the pulleys large, the leveling and alining being done on a horizontal system which enables the operator to work from the floor. An extra spirit level is attached to the face of the target by means of a special casting designed for the purpose. The target is hung horizontally on the shaft, supported with a stick grooved at

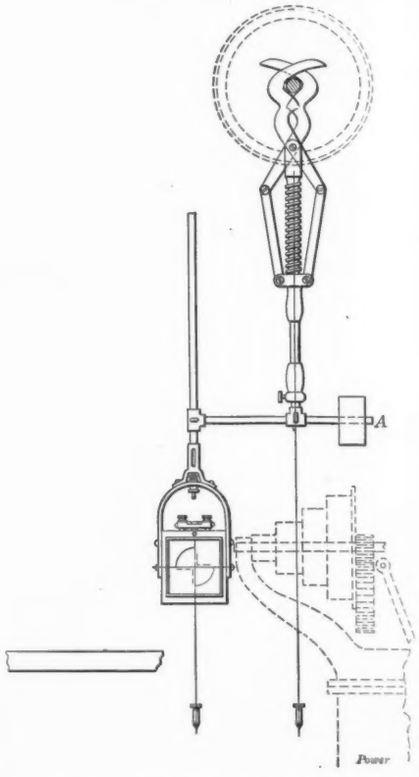


FIG. 4. SHAFTING HANGING FROM POSTS OR BEAM WITH OBSTRUCTION UNDER CENTER OF SHAFTING

the top, and by means of a thumb screw on the extra casting the spirit level is accurately adjusted. Then by plumbing from the center of the target a point on the floor is determined and a mark made. This operation is repeated every 12 inches along the shaft, and then the line is drawn. The architect's level is set over this line and the work of alining completed.

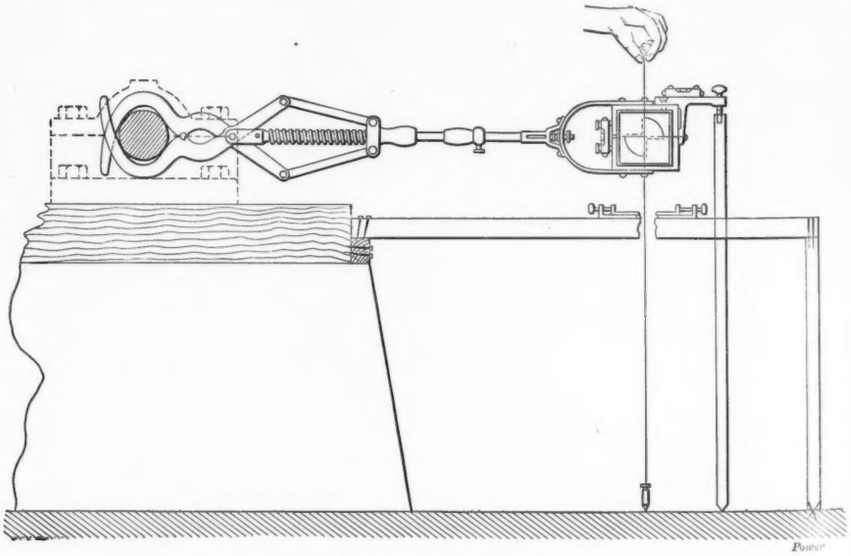


FIG. 5. ALINING PIER SHAFTING

Mud Drum Explodes

On July 16 a cast-iron mud drum exploded on a Babcock & Wilcox boiler at the plant of the Rochester Railway and Light Company, Rochester, N. Y., wrecking the boiler and injuring three men, one of whom will die. The drum ripped through the reinforced ligaments between the tube holes. Similar explosions have probably been due to initial shrinkage strains set up in the foundry by removing part of the sand while the casting was hot, thus exposing a part of the surface to the atmosphere while the rest was covered.

NEW PUBLICATIONS

ENGINEERING THERMODYNAMICS. By C. F. Hirshfeld. Published by D. Van Nostrand Company, New York, 1910. Boards; 160 pages, 4x6 inches; 22 illustrations. Price, 50 cents.

This is the second edition of Professor Hirshfeld's excellent little treatise. As the reviewer is unfamiliar with the first edition the relative merits of the two cannot be discussed. The intrinsic merit of the present edition, however, is extraordinarily high, despite a few rather inexact statements. The chapter on entropy, though covering only five of the small pages of the book, is one of the most lucid and accurate expositions of the subject that we know. The author does not follow the frequent slovenly practice of saying that entropy is equal to

$$\frac{dQ}{T}$$

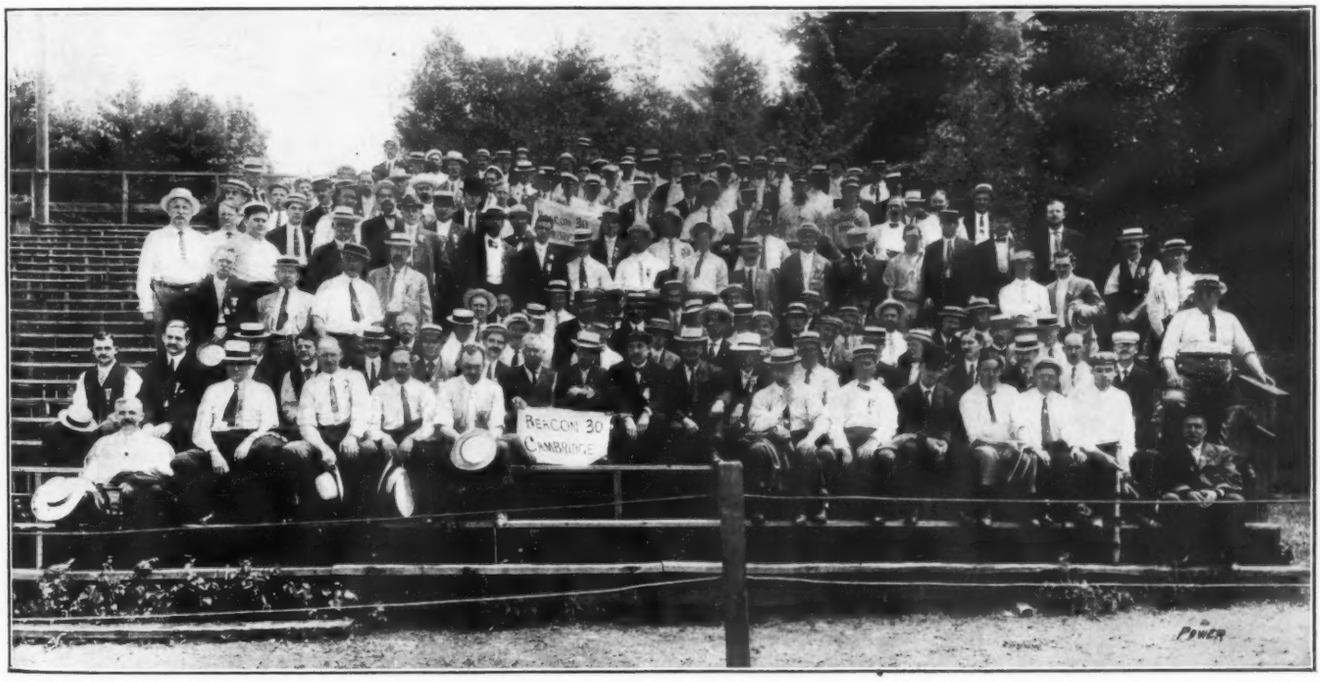
but carefully explains that this represents the *change* in entropy; that is, $d\phi$. True, he rather carelessly says that

$$\frac{dQ}{T}$$

"has received a name," but that is easily forgiven in view of the beautifully clean-cut discussion of the subject which follows.

The only important lapse that the reviewer has noticed is the inclusion of the mechanical equivalent of heat in the first law of thermodynamics, but this is common practice with textbook writers. Saddling a "law" with an approximation, however, does not give it the definiteness necessary to inspire respect. On page 39 the author states that work done (in foot-pounds) by the expansion of a gas is *equal* to the change in the sensible heat of the gas, which is not strictly true, of course; the formula immediately following, however, includes the coefficient (778) necessary to establish the mathematical equality.

The foregoing criticism is intended merely to indicate the small amount of effort necessary to eliminate flaws from this admirable little work; it is not due to any carping desire to find some slight excuse for adverse comment.



MASSACHUSETTS ENGINEERS AT N. A. S. E. STATE CONVENTION, REPORT OF WHICH APPEARED IN LAST ISSUE

PERSONAL

John A. Stevens, representing boiler-using interests, and William M. Beck, representing operating engineers, were reappointed by Governor Draper to the Massachusetts Board of Boiler Rules. Their services were apparently appreciated and both men are to be congratulated.

Sylvester S. Howell has become associated with Paul M. Chamberlain, engineer, Marquette building, Chicago, under the firm name of Chamberlain & Howell. The firm will carry on the designing and consulting-engineering practice establishment by Mr. Chamberlain.

L. R. Pomeroy has been appointed chief engineer of the railway and industrial division of J. G. White & Co., Inc., with headquarters in New York City. Mr. Pomeroy has for a long time been considered an authority on railway-shop equipment, operation and construction, and his attainments should form a valuable addition to the organization.

OBITUARY

John Denison Evarts Duncan died at Ann Arbor, Mich., on July 13. The news of his untimely death was a great shock to his many friends in New York, where he was widely known and highly appreciated. Mr. Duncan had been continuously associated with Sanderson & Porter, engineers and contractors, since February, 1901, and had acted as managing engineer of their New York office for the last six years. He was 39 years old. Mr. Duncan was a member of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Brooklyn Engineers Club, the Engineers Club of New York, the Machinery Club of the City of New York, the Michigan Club of New York, the University of Michigan Club, and the Cornell University Club.

SOCIETY NOTES

Rhode Island No. 2 National Association of Stationary Engineers will hold its fifteenth anniversary reunion, field day, shore dinner and entertainment at Palace gardens, Narragansett bay, on Sunday, July 31, 1910.

A genuine old-fashioned Rhode Island shore dinner will be served and everything which the judgment and foresight of the committee can devise for the entertainment of guests will be done. This anniversary is the New England event in National Association of Stationary Engineers' social functions and is sure to be largely attended as members and friends of the order are always guaranteed their "money's worth."

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

FLUID MOTOR. Archibald Kelso, Pittsburg, Penn. 963,581.

FURNACE. Albert A. E. Sterzing, New York, N. Y. 963,088.

MECHANICAL STOKER. William M. Duncan, Alton, Ill. 963,532.

SMOKE PREVENTER. Latimer H. Long, Louisville, Ky. 963,602.

FIRE BOX FOR BOILERS. James M. McClellon, Everett, Mass. 963,627.

GAS ENGINE. Frederick O. Kilgore, Minneapolis, Minn. 962,437.

FLUID PRESSURE IMPACT ENGINE. John Kincaid, Vancouver, British Columbia, Canada. 962,511.

HYDRAULIC MOTOR. Peter T. Coffield, Dayton, Ohio. 962,623.

MOTOR. Nathaniel Lombard, Winthrop, Mass. 962,711.

ROTARY ENGINE. Russell Clinton Leedham, Trinidad, Colo. 962,850.

STEAM ENGINE. John March, Dillon, Mont. 962,907.

ROTARY STEAM ENGINE. John Schuller and Andrew Niland, Hoquiam, Wash. 962,984.

GAS ENGINE. Samuel J. Webb, Minden, La. 962,995.

POWER PLANT AUXILIARIES AND APPLIANCES

BOILER ALARM. Alexander J. Aderhold, Birmingham, Ala. 963,028.

GOVERNING MECHANISM FOR TURBINES. Frederick Samuelson, Rugby, England, assignor to General Electric Company, a Corporation of New York. 963,074.

VAPORIZER OR CARBURETER FOR GAS ENGINES. Charles D. Shain, Rockaway Park, N. Y. 963,081.

GOVERNING MECHANISM FOR TURBINES. Charles H. Worsey, Lynn, Mass., assignor to General Electric Company, a Corporation of New York. 963,107.

VALVE. Charles W. Jones and James A. Gibson, Urbana, Ill. 963,152.

SYSTEM OF LUBRICATION FOR ELASTIC-FLUID TURBINES. Oscar Junggren, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 963,154.

CARBUREER. Frederick W. Tuerk, Chicago, Ill., assignor to the Tuerk Novelty Company, Chicago, Ill., a Corporation of South Dakota. 963,187.

SMOKE STACK. Annah Rockhill Clark, Spokane, Wash., executrix of Edward Thomas Jenkins, deceased. 963,208.

VALVE. Lewis Watson Eggleston, Chicago, Ill. 963,215.

MEANS FOR CONTROLLING THE VALVE MOVEMENT OF GATE VALVES. Dorville Libby, Jr., San Francisco, Cal., assignor to the Pelton Water Wheel Company, San Francisco, Cal., a Corporation of California. 963,230.

PIPE FITTING. Daniel S. Ramelli, New Orleans, La. 963,248.

GOVERNOR. Homer N. Motsinger, Pendleton, Ind., assignor to Motsinger Device Mfg. Co., Pendleton, Ind., a Corporation of Indiana. 963,309.

VALVE. Johnston Nolan, Philadelphia, Penn. 963,314.

STARTING VALVE FOR COMPOUND ENGINES. Wladimir Ivanovich Kovalsky, Stanzia Zdolbunoff R. R. Colony, Russia, assignor to Feodor A. Evdokimoff, New York, N. Y. 963,375.

PRESSURE REGULATOR. William Leuckert, New York, N. Y., assignor of one-half to Charles S. Hoffman, New York, N. Y. 963,376.

VALVE. Olaf E. Oleson, Chicago, Ill. 963,385.

AUTOMATIC SPRING PACKING. Alfred P. Sundt, Stoughton, Wis. 963,406.

HAND-HOLE SCRAPER. Henry B. Cockrell and Heyward B. Miller, Washington, D. C. 963,421.

LUBRICATOR. Linsey Vestal Hood, Gail, Tex. 963,441.

SUCTION VALVE FOR GAS ENGINES. Herman F. Mueller, Minneapolis, Minn. 963,463.

PIPE CONNECTION. George R. Bard, Chicago, Ill., assignor by mesne assignments, to the Waterworks Specialty Company, Chicago, Ill., a Corporation of South Dakota. 963,498.

PUMP. Fairleigh S. Dickinson, Rutherford, N. J. 963,528.

LUBRICATOR. Otto Hajek, Vienna, Austria-Hungary, assignor to the firm of Alex. Friedmann, Vienna, Austria-Hungary. 963,547.

VALVE OF INTERNAL COMBUSTION ENGINES. D'Arcy Victor Thomas Andrews Locke, Southbourne, England, assignor to Edwin James Castiglione, Carlisle, England, and Francis Cheney Bolton, Wandales, Eetheral, England. 963,600.

STEAM METER. Frank E. Pendleton, Montclair, N. J., assignor to Gamaliel C. St. John, Montclair, N. J. 963,643.

PACKING FOR PISTON RODS. John S. Pendleton, Lincoln, Ill. 963,645.

ROTARY PUMP. Frank J. Curtis, Ben Avon, Penn. 963,690.

STEAM SUPERHEATER. Ernest H. Foster, New York, N. Y. 963,732.

ELECTRICAL INVENTIONS AND APPLICATIONS

ELECTRIC BOND. Thomas J. Cope, Philadelphia, Penn. 963,035.

SYSTEM OF ELECTRIC METERING. Matthew O. Troy, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 963,096.

MOTOR-CONTROL SYSTEM. Henry B. Emerson, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 963,127.

STARTING DEVICE FOR ELECTRIC MOTORS. Harry H. Lee and Arnold E. Button, Schenectady, N. Y., assignors to General Electric Company, a Corporation of New York. 963,160.

LIQUID RHEOSTAT. Frederick Mackintosh, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 963,163.

LIGHTNING ARRESTER. Bertram H. Mann, Webster Groves, Mo. 963,233.

STORAGE-BATTERY SEPARATOR. Ervin M. Fitz, Columbus, Ohio. 963,284.

SPARKING DEVICE. Charles H. Stonebridge, New York, N. Y. 963,334.

ELECTRICAL SYSTEM OF DISTRIBUTION. William A. Turbayne, Lancaster, N. Y., assignor to oGuld Storage Battery Company, a Corporation of New York. 963,339.

RELAY. Isidor Kitsee, Philadelphia, Penn. 963,374.

SLACK SPOOL FOR ELECTRIC WIRING. Henry Van Altena, New Brunswick, N. J. 963,966.

ARRANGEMENT FOR STARTING AND REGULATING THE SPEED OF ALTERNATING-CURRENT MOTORS. Engelbert Arnold, Karlsruhe, Germany, and Jens Lassen LaCour, Edinburgh, Scotland. 963,678.

POWER PLANT TOOLS

LIFTING JACK. John H. Burkholder, Ashland, Ohio, assignor to the Elite Manufacturing Company, Ashland, Ohio, a Corporation. 963,206.

WRENCH. Benedict Goodman, Wallace, Kan. 963,287.

WRENCH. Robert Earl Harshell, Georges Station, Penn. 963,550.

WRENCH. William E. Elliott, Sault Ste. Marie, Mich. 963,700.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., W. W. Freeman, Brooklyn, N. Y.; sec., T. C. Martin, 33 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U .S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railway, Cleveland, O.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Rochester, N. Y., September 12-17, 1910.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August 2-5, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, 606 Main St., Peoria, Ill. Next convention, Denver, Colo., September, 1910.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

BUSINESS ITEMS

George H. Kendrick, formerly with the H. W. Johns-Manville Company, has been appointed New England sales manager of the Crandall Packing Company, with offices at 19 High street, Boston, Mass.

The Peerless Motor Car Company, Cleveland, Ohio, and the Buick Motor Car Company, Flint, Mich., have recently purchased Swartwout cast-iron exhaust heads and centrifugal separators from the Ohio Blower Company, Cleveland, Ohio.

A. K. Waycott, formerly with the Crandall Packing Company, has been elected president of the Argo Supply Company, with offices at 136 Liberty street, New York. This company handles engineer and mill supplies, and steam-engineering specialties.

The Jefferson Union Company, of Lexington, Mass., has recently prepared a catalog on its style F male and female union. This is ready for distribution and will be sent on request. It is also preparing a catalog on its new swing union, which is almost a universal union. This will be ready for distribution in the very near future.

The Gleason Works, Rochester, N. Y., has awarded contract to the C. & G. Cooper Company, Mt. Vernon, Ohio, for a 375-horsepower simple Corliss engine to be installed in the new power house. This engine will drive a direct-current 250-kilowatt generator and furnish power for the Gleason Works, including the extensive additions now being made.

The Precision Instrument Company has been incorporated at Detroit, Mich., to manufacture CO_2 recorders and other instruments under the patents of Alexander Wright & Co., of England. The officers of the company are president, Andrew H. Green, Jr.; vice-president, V. F. Dewey; secretary and treasurer, Abram T. Baldwin; general manager, M. Woolsey Campau.

At the recent convention of the International Association for the Prevention of Smoke, at Minneapolis, Minn., R. S. Riley, president of the American Ship Windlass Company, Providence, R. I., read an instructive paper on "Taylor Stokers and Steam Boiler Efficiency," in which he showed by numerous illustrations the principles of construction and operation in their relation to increased efficiency.

The Mine and Smelter Supply Company, who maintain large offices and warehouses at Denver, El Paso and Mexico City, with executive offices at 42 Broadway, New York City, announce it has taken over the agency for the entire western territory of the United States of the line of pumps made by the Epping-Carpenter Company, Pittsburg, and the line of compressors made by the Bury Compressor Company, Erie, Penn.

The De La Vergne Machine Company has opened a new office at 380 Bourse building, Philadelphia, Penn., and has appointed Hy. J. Engel to take charge of it. He will represent them in Pennsylvania and some of the surrounding States. Mr. Engel has been connected with the company for a good many years, is a mechanical engineer and has a long and varied experience in the refrigerating line. The company has also opened an office at 1124 Chandler building, Atlanta, Ga., which will be in charge of Wm. Hargreaves, who will represent it in the southern district, which territory he is very familiar with on account of having acted as its agent there up to two years ago when it closed its Atlanta agency.

The Atlas Water Tube Boiler Company has opened general offices in the Franklin Bank building, Philadelphia, Penn. The officers of the company are B. J. Morrison, president; H. A. Scattergood, secretary and treasurer; George R. Harvey, general manager. This company has taken over all rights and patents of the Atlas water-tube boiler, formerly manufactured by the Atlas Engine Works, of Indianapolis, Ind. The new company will devote its energies exclusively to the manufacture of this boiler, of which there are now installed in this country something over 250,000 horsepower. It will be recalled that the Government power plant, at Washington, D. C., just recently turned over, is equipped with 16 (550 horsepower each) Atlas boilers, which is said to have been the largest single order for boilers ever placed by the Government.

The International Acheson Graphite Company, of Niagara Falls, N. Y., has arranged to erect a very substantial and large addition to its works on the lands of the Niagara Falls Power Company in that city. The addition will be in the nature of a furnace room, which will afford capacity for 10 or 12 new furnaces. The building will be of brick and steel construction and erected to the west of its present works, where there is ample room for still further enlargement. The additional furnaces will make possible a very large increase in the output of graphite, and is indicative of the constantly increasing recognition of the value of the products of the company. These products are electrodes for electrochemical, metallurgical and electrical purposes, and powdered graphite for dry-cell filler, paint pigment, powder glazing, lead pencils, firearms lubrication, general lubrication, electrotypers' molding and polishing leads, etc.

The Berlin Construction Company has received the contract for rebuilding the fan shop of the Green Fuel Economizer Company, at Matteawan, N. Y., which was almost totally destroyed by fire some weeks ago. It is expected to have the new building erected and complete, ready for occupancy, about the middle of August. The new shop will have about 25 per cent. more floor space than the old shop, including a test room fully equipped with chambers, gages, etc., suitable for making exhaustive tests on the capacity, pressure and efficiency of the improved fans built by this concern for heating and ventilating, mechanical draft and other services. The new building will be of steel construction throughout and will be heated by the hot-blast system, with frequent outlets near the floor to secure uniform distribution of the heat. This system has been applied by the Green Fuel Economizer Company with great success in several buildings that were peculiarly difficult to heat, such, for instance, as the new foundry of the Waterbury Castings Company, where the wall surface is almost entirely of glass.

NEW EQUIPMENT

The city of Decatur, Neb., is contemplating installing waterworks.

The city of Yukon, Okla., voted $30,000 bonds for waterworks.

Hotel Rudolf, Atlantic City, N. J., will install two more boilers.

The city of Belleville, Ont., will equip a new electric-light station.

The Granite (Colo.) Tunnel Company will build an electric power plant.

The Cudahy Packing Company is erecting a new building at Portland, Ore.

The Snyder (Tex.) Ice, Light and Power Company will build a new power house.

The town of Munday, Tex., has voted the issuance of $10,000 bonds for waterworks.

The Peoples Power Company, Moline, Ill., is erecting a $500,000 gas- and electric-light plant.

The Wheeling (W. Va.) Traction Company will shortly commence work on a new power house.

Hartselle, Ala., will vote on issuing $28,000 bonds for an electric-light plant and waterworks.

The city council, of Madisonville, Ky., voted in favor of installing a waterworks system.

The city of Mansfield, Okla., will vote on the question of issuing $20,000 bonds for waterworks.

The Providence (R. I.) Dyeing, Bleaching and Calendering Company will enlarge its boiler house.

The Dubuque (Iowa) Packing Company will build a new plant to be operated by electric power.

The city of Oceanside, Cal., will vote on the issuance of $15,000 for improvements to its waterworks.

The Northern Illinois Electric Railway Company will erect a large power house at Lee Center, Ill.

The citizens of Belgrade, Neb., voted to issue $18,000 bonds for an electric-light plant and waterworks.

Plans for a waterworks plant at Conway, Ark., have been accepted and bids will be advertised for soon.

Lake Arthur, La., will install a small system of waterworks. Address J. B. Streator, chief, fire department.

Two hundred thousand dollars will be spent on improvements in the water, light and sewer system at Altus, Okla.

The Alabama Canning Company, Mobile, Ala., is said to be contemplating the installation of an electric-light plant.

The Kooskia (Idaho) Land and Power Company will build a hydroelectric plant of about 5000 kilowatts capacity.

The citizens of Roseville, Cal., voted to issue $90,000 bonds for electric-light and power plant and sewer system.

Bids will be received August 4, at the office of the city clerk, Gadsden, Ala., for building new waterworks plant, for which $60,000 bonds were voted recently.

NEW CATALOGS

The Ohio Brass Company, Mansfield, Ohio. Pamphlet. Ohio radiator valves. Illustrated, 8 pages, 3x6 inches.

The Canton-Hughes Company, Canton, O. Catalog No. 25. Steam pumps and hydraulic machinery. Illustrated, 120 pages, 5½x7 inches.

L. J. Wing Manufacturing Company, 90 West street, New York. Bulletin No. 7. Typhoon turbine blower. Illustrated, 20 pages, 6x9 inches.

Pennsylvania Flexible Metallic Tubing Company, 1305 Arch street, Philadelphia, Penn. Booklet. Interlocking metal hose. Illustrated, 22 pages, 3½x6 inches.

C. W. Hunt Company, West New Brighton, N. Y. General Catalog No. 102. Coal-handling and hoisting machinery, conveyors, electric and steam hoists, etc. Illustrated, 112 pages, 4x6½ inches.

Sprague Electric Company, 527 West Thirty-fourth street, New York. Bulletin No. 600. Single and polyphase induction motors. Illustrated, 40 pages, 8x10½ inches. Form No. 517. Flexible steel-armored hose. Illustrated, 10 pages, 3½x6 inches. Form No. 322-A. Electric fans. Illustrated, 20 pages, 3½x6 inches.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power and the Engineer.

How often do you take advantage of the opportunities offered in the advertising sections of POWER of getting into close and complete touch with fresh and vigorous ideas, with the newest developments in power plant equipment, by sending for the catalogs, booklets, souvenirs and samples which the advertisers invite you to have at their expense?

There can be no doubt but that the great bulk of engineers and other power plant operators appreciate the great advantage of buying their equipment through good advertising mediums. Returns from the advertising pages of POWER prove that conclusively.

But it is not so clear that there is a full realization of *all* the opportunities of keeping abreast of the times through the free matter offered by advertisers.

There are people who are afraid of anything that is free, who argue that the only things worth having—especially in business—are those paid for in good hard cash, and that everything else had best be avoided. Hence, they don't send for the free catalogs, etc.

Then there are also men whose very life in business depends upon their up-to-dateness in their special field, who fail to take advantage of the opportunities offered in the invitations to get "full details," simply because they do not realize the great advance made in printed salesmanship during recent years.

Advertisers pay good money for space in POWER in order to put the *main* facts about their product in your hands, because they have confidence that their product is something that you *really* need.

That same confidence of genuine merit is also the thing that prompts the advertiser's desire to go to the additional expense of putting the *full and complete* facts in your possession by means of free catalogs, booklets, souvenirs and samples.

And, furthermore, it is your best evidence that the something which he wants to send you, without charge, is *worth having*.

Catalogs and booklets on power plant equipment have undergone much the same evolution, in recent years, as has advertising copy on the same class of products.

Examine the ads. in any number of POWER. Instead of mere publicity notices—names, addresses and a picture—the POWER ad. sections contain page after page of meaty information, just the matter that the POWER plant man *needs* for wise buying.

The same thing has come to be true of the printed salesmanship that follows the ad.—if you will let it. Not price lists. Not bald claims with no evidence. But clear, full statements of *ideas, facts, reason why*.

Good money and good brains go into them. They offer—with the advertising copy—the best method of getting the full story of what is being done by progressive men in your line.

That they are free is no reason why you should be skeptical of them. It is simply the strongest proof of the *real* merit of the matter which they contain.

Free souvenirs, engineering handbooks, samples and the like, have also undergone an evolution. They, too, now have their story to tell.

The leading features of many a product can often be strikingly displayed in some handy little article.

Again, if the advertiser has the confidence in the *real* worth of his product to go to the still further expense of adopting this pleasant method of presenting his case, why not take him up? You have everything to gain and nothing to lose!

Nor does the advertiser lose. He realizes that the circulation of his advertising matter among power plant men means a practically "wasteless" circulation.

The whole matter comes right down to this point: You *must* take *full* advantage of progressive printed salesmanship if you are to win your full measure of business success.

And the best way to do it is to read the POWER ads. carefully and then get the *full* story from the advertisers who want to give it to you.